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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B ALFRED RAWORTH.

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See page 94, Feb. 9. 3751

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See Advertisement page 25. 5207

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See Full Page Advt. page 66, Feb. 9.

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WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
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Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

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Pott, Cassels & Williamson,
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See half-page Advertisement page 19, Jan. 26.

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For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
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Founded 1854 by Sir W. Fairbairn.
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Prospectuses and full particulars of the following may be obtained on application to the REGISTRAR: Engineering, Electrical Engineering, Civil Engineering, Naval Architecture, Marine Engineering, Engineering Design and Drawing, Refrigeration, Mathematics, Physics, Inorganic Chemistry. G 103

The Otto Coke-Oven Company, Limited.

NOTICE IS HEREBY GIVEN that all the Shares formerly held in this Company by enemy aliens have been Purchased from the Public Trustee by the existing British Shareholders.

The Company is therefore now
ALL-BRITISH,
with regard to its Proprietary, Management and Staff.

W. H. PYECROFT,
Commercial Manager and Secretary.

G 163

TENDERS.

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—
SHEFFIELD TOOLS, &c.
HEMP.
GALVANIZED WROUGHT IRON WATER TUBES, &c.
BIB COCKS, &c.
PLATELAYERS' TOOLS.

Specifications and Forms of Tender may be obtained at this Office on payment of the Fee for the Specification, which payment will not be returned.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Sheffield Tools, &c.," or as the case may be, not later than Eleven o'clock, a.m., on Thursday, the 22nd February, 1917.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.
Company's Offices,
48, Copthall Avenue, London, E.C.
14th February, 1917. G194

TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

SALE BY TENDER.

The PUBLIC TRUSTEE invites

Tenders for the Purchase of

the WHOLE or ANY PART of 83,408 SHARES of £1 each, 10s. called up, and 81 Shares of £1 each, fully paid, in the BRITISH RAILWAY TRAFFIC and ELECTRIC COMPANY, Limited, vested in him as custodian by an Order of the Board of Trade dated the 31st July, 1916. The total issued capital of the Company is £50,059 in 99,900 shares of £1 each, 10s. called up, and 100 shares of £1 each fully paid. There are no debentures or other charges on the assets. The Company commenced trading in the beginning of the year 1904, and until the year 1910 the business consisted of the provision of railway rolling stock both on the simple hire system and on the hire purchase system. From the year 1910 the Company's operations have been extended to the supply of Commercial Motor Vehicles on hire purchase terms.

For the three years ended 31st December, 1915, the average yield of net profit on the capital issued has been about 10 per cent. before providing for Directors' Fees or making allocation to reserve. The average dividend paid for the same three years has been over 7 per cent. per annum. The Company holds a considerable stock of wagons on simple hire and hire purchase, all of which are in main-line running order.

The Offices of the Company are situate at 25, Victoria Street, London, S.W.

Tenders must be delivered sealed to the Public Trustee, Kingsway, London, W.C., not later than Twelve o'clock Noon on Friday, the 23rd February, 1917, and marked on the envelope "Tender for British Railway Traffic and Electric Co., Ltd., Shares." The Public Trustee does not bind himself to accept the highest or any Tender.

Forms of Tender can be obtained from the PUBLIC TRUSTEE; or from Messrs. W. B. PEAT & Co., 11, Ironmonger Lane, London, E.C. On the instructions of the Public Trustee, a short report on the Company has been prepared by Messrs. W. B. PEAT & Co. This may be seen either at their offices or at the offices of the Public Trustee. G 197

Tenders for the Purchase of

the Whole or any part of 119,680 Shares of £5 each, fully paid, in SIEMENS BROTHERS & COMPANY, LIMITED, IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

The PUBLIC TRUSTEE invites

Tenders for the Purchase of

the Whole or any part of 3,579 "A" Shares of £10 each, fully paid, and 1,200 "B" Shares of £10 each, fully paid, in the TUDOR ACCUMULATOR COMPANY, LIMITED, vested in him as Custodian by an Order of the Board of Trade, dated the 2nd October, 1916.

The issued capital of the Company consists of 3,900 "A" Shares of £10 each, fully paid, and 1,200 "B" Shares of £10 each, fully paid.

The purchasers, who must be British-born subjects, will be required to make a sworn Declaration as to nationality and freedom from foreign control on a form to be obtained from the Offices of the Public Trustee.

A report upon the result of the past operations, and the present position of the Company, has been made to the Public Trustee by Messrs. KNOX, CROPPER & COMPANY, Chartered Accountants, of Spencer House, South Place, E.C., and this report, together with copies of the Company's Accounts, can be inspected either at the Offices of the Public Trustee, Kingsway, W.C., or at those of Messrs. KNOX, CROPPER & COMPANY.

Tenders must be delivered, sealed, to the Public Trustee, Kingsway, W.C., on or before Monday, the 26th February, 1917 (instead of 5th February, as previously advertised), at Twelve Noon, marked on the envelope, "Tender, Tudor Shares."

The Public Trustee does not bind himself to accept any Tender, and reserves to himself all rights in connection therewith. G 147

Forms of Tender can be obtained from the PUBLIC TRUSTEE, or from Messrs. KNOX, CROPPER AND COMPANY, Spencer House, South Place, E.C

APPOINTMENTS OPEN.

Superintending Marine

ENGINEER REQUIRED by the Government of British Guiana, to superintend a service of river steamers. Salary £400-£30-£500, with additional £75 per annum whilst acting as Public Works Department Officer. Engagement on agreement for three years, with possible extension. Free first-class passages. Candidates must have served an apprenticeship with a firm of marine engineers, hold not less than a first-class Board of Trade certificate, have a thorough knowledge of marine construction and repairs both to hull and machinery and have experience in the administration and supervision of engineering shop and foundry. Experience in the running of marine engines on oil fuel desirable.—Apply at once by letter, giving full particulars to Messrs. FLANNERY, BAGGALLAY & JOHNSON, Ltd., 9, Fenchurch Street, London, E.C. No person engaged on Government work need apply. G 167

Foundry Manager Wanted.

Must be capable of taking charge of drawing office, pattern shop, moulding shops, warehouses &c.—Address, BOX 138, T. B. BROWNE'S Advertising Offices, 163, Queen Victoria Street, London. G 201

Wanted, Assistant Works

MANAGERS for large Aeroplane Works, London District. Good opening for men with experience in engineering shop management. Commencing salary, £500 per annum.—Address, G 183, Offices of ENGINEERING.

Wanted, at Once, Assistant

MANAGER, for Ship and Engine Repair Works on North-East Coast; must have experience.—State full particulars and salary required, in first instance, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 2920. No person already on Government work will be engaged. G 193

Superintendent of "Stores"

WANTED, for a National Factory in South Yorkshire, must be experienced in stores book-keeping and stores organisation. Competent to control men.

Applicants employed on War work will only be considered with the sanction of their present employers. Must be ineligible for the army.—Address, stating age, experience, and salary required, to G 195, Offices of ENGINEERING.

Wanted, First-class Experienced Storekeeper,

to take entire charge at large Iron and Steel Works in Midlands. Full particulars to G 168, Offices of ENGINEERING.

Wanted, for Steel Foundry

in North of England, thoroughly experienced METALLURGICAL CHEMIST with knowledge of electric furnace practice. Good opening for capable, energetic man. No one at present employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning ENGINEERING and G 172.

Wanted, Capable Chemist,

with good references, accustomed to Analysing materials used in railway works.—Applicant to state age and salary expected to G 179, Offices of ENGINEERING.

Wanted, Assistant Chemist,

one used to analysis of non-ferrous alloys preferred.—Reply, stating age, experience, and wage required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 2926. No person already on Government work will be engaged. G 182

Buyer's Assistant Wanted for

Engineering Works. Must be smart, energetic, and capable of dealing with duties attached to this post. Experienced in general buying and stores routine. Motor Car and Aero Engine experience an advantage. No one employed on Government work or eligible for Military service will be engaged.—Apply, nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 180.

COLCHESTER JUNIOR TECHNICAL SCHOOL.

Wanted, Teacher of Engineering

(ineligible for Military service). Must be experienced in machine work, wood work, metal work, and drawing.

To commence duties about April 30th.

Salary, £130 per annum.

Applications, stating workshop and teaching experience, together with copies of three testimonials, not later than February 28th.

G. C. HOLLAND,
Secretary,
Technical College,
Colchester. G 129

Carbon Electrodes.—Engineer

or FOREMAN REQUIRED, conversant with the manufacture of large carbons for electric furnaces. No person resident more than 10 miles away, or already engaged on Government work will be engaged.—Write, V, Box 333, care of JUDD'S, 97, Gresham Street, London, E.C. G 191

Required, an Experienced

fully qualified ENGINEER, capable of supervising and carrying through road making, surveying estates' water supplies, drainage, buildings, transport arrangements, erection of machinery, and all engineering, surveying and constructional work required in the development of large Rubber Estates in the Malay Peninsula. Good salary and generous treatment will be given to a really capable first-class man whose knowledge, experience and ability would fit him for such a post.—Apply, in first instance, with full particulars in strictest confidence, to BOX No. 7996, care of A. J. WILSON and Co., LTD., 154, Clerkenwell Road, London, E.C. G 157

Wanted, First-class Blast

FURNACE ENGINEER (British). One conversant with modern American and Continental practice preferred.—Address, stating age, experience, and salary expected to G 83, Offices of ENGINEERING.

Engineer Wanted for Abroad.

Knowledge of refrigeration by Ammonia process desirable. No one already engaged on Government work need apply. Reply with copies of testimonials, stating age, if married or single, and details of experience, to "T." Box 121, T. B. BROWNE'S Advertising Offices, 163, Queen Victoria Street, London, E.C. G 119

Wanted, Engineer and Fitter

for institution in Kent (ineligible for military service). Must be a well-trained mechanic capable of taking charge of small steam plant, laundry machinery, electric lighting, &c.

Applications, together with full particulars as to age, experience, and wages required to W. J. PERKINS, Consulting Engineer, 38, Victoria Street, S.W. G 202

Royal Midland Counties Home

for Incurables, Leamington.—WANTED, ENGINE MAN, with experience, for Lancashire boilers, lifts, laundry, and general work of the home.—Apply, SECRETARY. G 113

An Assistant Engineer is

REQUIRED for estimating work, the qualifications of which are: A sound technical knowledge of electrical plant and apparatus, preferably having some testbed or practical experience in the operation of plant. Applicants must be energetic, accurate in figuring, and must have had previous experience in the preparation of tenders and estimates for customers from works' costs. Applicants should be exempt from military service if possible. Age, details of experience and present employment and salary required must be given, and also the date when the applicants would be free. No person at present employed on Government work need apply.—Write or call your nearest EMPLOYMENT EXCHANGE, giving full particulars, quoting No. A 2917. G 169

Rate Fixer, for Bench Filing

and Fitting; N.W., London. Good prospects for a live man with experience. No one resident more than 10 miles away will be engaged.—Apply in writing, giving full details of past experience and wages required, to G 185, Offices of ENGINEERING.

Draughtsman, Mechanical,

Wanted, to take leading position in Drawing Office in new Company in Midlands engaged upon urgent War Work. Excellent prospects for a young energetic man. One with some experience in jig and tool design and automobile construction preferred. No man on Government work can be engaged without consent of present employers. Applications in the first instance should be made to the nearest Board of Trade EMPLOYMENT EXCHANGE, mentioning this paper & No. A 2713. F 982

Wanted, Draughtsman for

Controlled Establishment. One with knowledge of grinding and seed crushing plant preferred but not essential. No one already engaged on Government work need apply.—Apply, stating full particulars and salary required, to your nearest LABOUR EXCHANGE, mentioning this Journal and F 995.

Wanted, Draughtsmen for

Turbine details and arrangement at Controlled Works. Salary according to experience. No one on Government work will be engaged.—Apply, nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 121.

Wanted, Capable Draughtsman,

accustomed to switchgear design; must be a quick worker and have a sound mechanical knowledge.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Paper and No. A 2880. No person on Government work will be engaged. G 120

Required, the Services of Four

Skilled DRAUGHTSMEN, accustomed to either Blast Furnaces or Steelworks constructional design. Good salary offered to suitable men. Applicants should state age, experience, salary required, and when at liberty. No one engaged at present on Government work need apply.—Apply, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 2739. G 122

Wanted, Jig and Tool

DRAUGHTSMEN, also Draughtsmen for Aeroplanes and Engines. London, N.W. State age, experience and salary expected. No one resident more than ten miles away or engaged on Government work need apply.—Address, G 171, Offices of ENGINEERING.

Several Good Mechanical

DRAUGHTSMEN REQUIRED for Admiralty Establishment. Accustomed to small high-class work preferred. Salary according to ability.—Write, stating experience, age and present position, to BOX No. 970, care of Messrs. R. F. WHITE and SON, Genl. Advtg. Agents, 53, Fleet Street, London, E.C. G 136

Wanted, Nine Draughtsmen.

Preference given to those with experience in Coke Ovens, Blast Furnaces, Steel Furnaces or Rolling Mills.—Apply, giving full particulars as to experience, &c., to your nearest EMPLOYMENT EXCHANGE, quoting A 2941. G 137

Mechanical Draughtsmen,

WANTED IMMEDIATELY, for a Government-Controlled Aircraft Works in South-West of England. Aircraft experience desirable, but not essential. No person already on Government work will be engaged.—Apply, giving full particulars as to training, age, salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 2940. G 165

Draughtsmen Required

immediately for Government Aeronautical Work. Shop and D.O. experience; also technical training essential. Good salary and prospects. No man on Government work or eligible for Military service need apply.—Write or apply your nearest EMPLOYMENT EXCHANGE, quoting No. A 2935. G 170

Draughtsman for Reinforced

Concrete work WANTED immediately; London, W.C. No person already employed on Government work will be engaged.—Address, stating age, experience, and salary required, G 184, Offices of ENGINEERING.

Wanted, an Assistant, in a

Second-hand Machinery Merchant's Office, in London.—Address, G 144, Offices of ENGINEERING.

A Large Firm of Engineers,

in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of ENGINEERING.

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Works Manager, 43, Practical

and Commercial, DESIRES POST; 25 years' experience in high class steel foundries and steel works engaged on all classes of material.—Address, G 101, Offices of ENGINEERING.

Engineer, Manager, Seeks

POSITION, fuse, shells, gun, tool work, &c., 20 year's experience in management. Age 50. Salary £700 and Bonus.—Address, G 64, Offices of ENGINEERING.

Steel Castings by any Process.

Expert Manager OPEN to ENGAGEMENT. Full practical and technical knowledge. Absolute success guaranteed.—Address, G 190, Offices of ENGINEERING.

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electrical or mechanical engineers, who has specialized in the purchasing of engineering supplies, is OPEN to an ENGAGEMENT.

Experience has been with large engineering undertakings. Good technical knowledge of materials. Wide acquaintance with the markets for the supply of raw and finished materials, finished components, machine tools and all general stores. Would undertake the reorganization and systematizing of purchasing department.—Address, G 118, Offices of ENGINEERING.

Foreman or Assistant Manager

REQUIRES SITUATION, munition preferred, expert at machines, used to large staff, life experience, excellent refs.—Address, G 196, Offices of ENGINEERING.

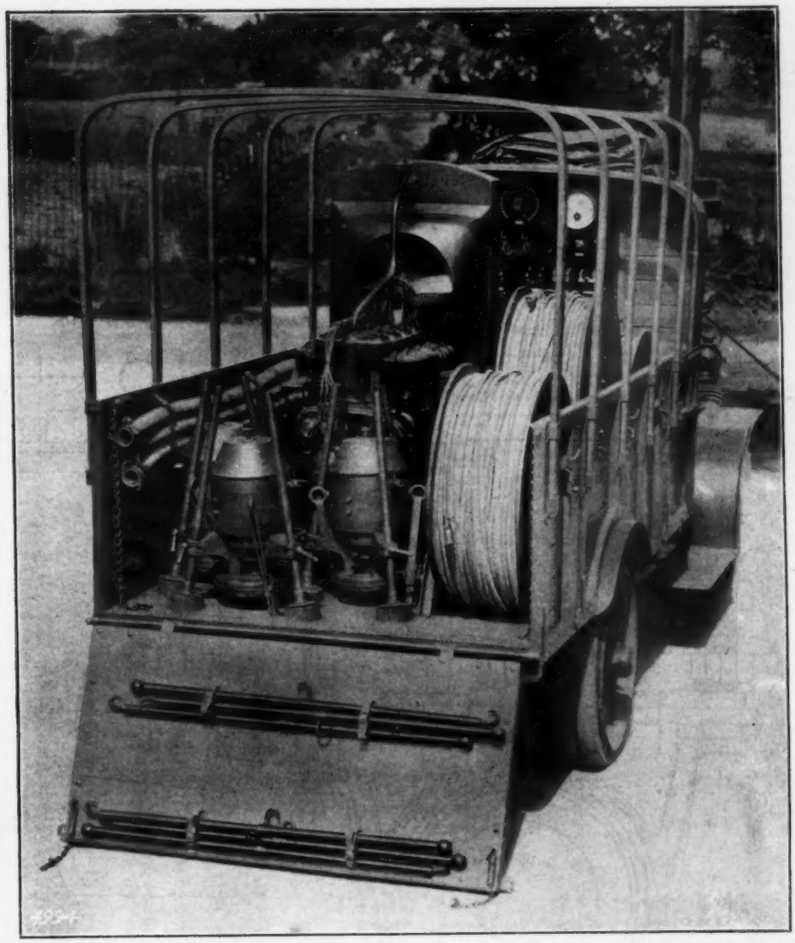
Advertiser Desires Engagement,

Manager or Assistant, hydraulic machinery, constructional iron work, shell making. London or near preferred, over military age.—Address, G 203, Offices of ENGINEERING.

AUSTIN MOTOR LORRY AND TRENCH PUMP.

THE AUSTIN MOTOR COMPANY, LIMITED, BIRMINGHAM.

(*For Description, see Page* 149.)



THE ARRANGEMENT OF MACHINE SHOPS.—No. X.

By JOSEPH HORNER.

NOTWITHSTANDING the rivalry of new designs of shaft bearings, large numbers of the old rigid types of plummer blocks—bearings fitted with brasses—remain in service. But, generally, these are superior to their prototypes, being of greater length in proportion to diameter, and having provision for more ample and automatic lubrication. Babbitt is sometimes substituted for brass, and ring-oiling is common.

Faced by the numerous alternatives in bearings which are now offered, firms may be expected to proceed on diverse lines. The numerous experiments which have been recorded, and the contradictory results claimed on behalf of rival systems of bearings, are not very helpful. The conditions under which these experiments have been made and the rougher shop conditions are often at variance. At the present time shop shafting is run with rigid bearings, with swivelling bearings with or without ring-oiling, with fluid and with solid lubricants, with ball bearings and with roller bearings, the latter being both of rigid and of elastic types.

It must be remembered when making comparisons that working conditions are now generally better than those which existed in most shops some years ago, so that the whole of the credit for present-day higher economies may not be justly claimed on behalf of the new bearings themselves. In the old shops, when the roof principals were often of timber and the walls of masonry, two conditions that were unfavourable to permanent alignment were present. The timber inevitably warped, and the walls sunk unevenly or shifted laterally, and the shaft bearings attached to either participated in these movements. Some re-alignment became necessary at uncertain intervals, and if that correction was neglected, trouble consequent on increased friction and scoring of brasses was inevitable. A slight degree of departure from strict alignment is sufficient to cause troubles of these kinds, especially when it occurs in conjunction with the pull of belts that are too tight or too short. The employment of light steel roof principals and of rigid columns of the same material has greatly reduced the risks of departure from the linear relations of bearings. Consequently these features have been so far favourable to the retention of the rigid designs.

Two movements which antedated the introduction of the ball bearings with point contact, and the roller bearings with line contact, have exercised an immense influence for good on the older bearing designs. Long since it was recognised that the friction of bearings might be reduced per unit area by increasing their length, and this was generally adopted in practice. At present, transmission firms will supply either short or long bearings to customer's requirements. But a movement which exercised larger and far wider-reaching results was that of the employment of the Sellers' swivelling bearings, which afford some amount of accommodation for shafts that are not in strict alignment. The precise method adopted to secure the swivelling movement has been varied since in new designs, but the principle itself is retained in all. Associated with it, too, is the increase in the length of the bearings which, in maximum proportions, was embodied in the original Sellers' designs.

Another initiative movement of immense importance consisted in the substitution of continuous lubrication for that of the oil cup and oil can. It has developed several varieties, that of oil cups and capillary necks, of solid lubricants with or without pressure, of a reservoir with automatic ring-oiling, and that of an enclosed bath of oil—each main type being made in varied designs. The first-named type is being used less and the three others far more commonly than formerly. But in each a great feature is that the casual daily oiling is abandoned, and in the last-named two the lubrication is most ample and it is continuous, so that the risk of bearings becoming hot and seizing is practically eliminated. Also in the old bearings the lubricant was lost and wasted after use, and often dropped on the floors below. In the self-oiling designs it does service over and over again, and may then be recovered and cleaned for further use. The saving effected in the cost of lubricant, added to the improved efficiency and lessened risk of overheating, may in favourable cases go a long way towards repaying the higher costs of the better bearings.

Although the adoption of ball bearings, and that of roller bearings in a lesser degree, has extended for shop shafting, a good many firms prefer to retain the rigid self-aligning bearings, with or without ring-oiling. In order to understand this fact the subject must be regarded in all its aspects.

In the first place the terms "ball" and "roller" bearings only denote great classes or types, each of which includes many designs. In the second they have passed through a period of evolutionary change which has been marked by many improvements. So that the bearings of to-day are not like the earlier ones. They embody valuable details that have been born of failures and have been suggested by experience. Three essentials there are that contribute to efficiency—the character of the design itself, a very high degree of approximation to accuracy of outline, and a suitable heat treatment. The conditions also under which bearings are installed must have considerable influence when a selection is being made. We may briefly consider these essentials in turn. In general the designs should fulfil the following requirements if they are to compete successfully with and displace existing older installations—for that, in many instances, is the question to be decided.

The superiority and the economy of the rolling over the sliding friction in the bearings which they displace must be maintained throughout the life of the ball and roller bearings if they are to retain permanently the initial advantage which they undoubtedly possess. This means that they must not suffer distortion or wear sensibly during a reasonable length of service. Objections have been made to balls on the ground that they develop flats, and to rollers that they wear unequally, chiefly about the centre, in consequence of their taking up a position slightly crossways in their cages or races. When either of these results occurs the evil does not cease with the unequal wear of the bearings, but the shaft journals themselves become scored and damaged, and the friction is consequently increased.

In order to avoid these evils the numbers of balls or rollers are increased so far as is practicable for any one size of shaft, consistently with the prevention of actual contact occurring between them. Also, in ball bearings considerable variations have been made in the cross-sections of the paths that are shaped in the races in order, first, to afford sufficient bearing surfaces, and, second, to ensure nearly equal amounts of rolling in the two races, to the exclusion of sliding friction in one of them. These details are generally familiar, having been discussed and illustrated in many papers on the subject.

Another essential is the self-alignment of bearings, by which excessive and destructive friction is

prevented. This occurs when shafts become deflected either by their own distortion, or by those movements of bearings which are caused by the subsidence of column foundations or by lateral movements. These may be due to temperature changes in girders, to the pull of heavy belts, to wear of journals or bearings, to insecure bolts, or other causes operating on shafting and bearings, which are extremely sensitive to departures from strict alignment.

No rigid bearing can be self-aligning, though when a rigid bearing is mounted in a swivel seating, fairly satisfactory results are secured. But ball bearings have the advantage here because they not only supply point contact, which contact is carried over only a very short length of shaft, but they are usually mounted also in a swivel plummer block, or in a swivel hanger. The longer the rigid bearing is made in order to reduce the unit pressure, the more necessary is the occasional scraping of brasses to retain good bedding, the more severe is the friction when it is out of alignment, and the greater is the risk of consequent damage occurring to shaft and bearing. From these evils the ball bearings, with their point contact, are free, and they are therefore of especial utility in cases where shafting is badly out of alignment, or is liable to get into this condition. Incidentally, too, less length of shafting is taken up in the bearings themselves than in the rigid types, which is a consideration in large installations.

This argument does not appeal quite so strongly in favour of the roller bearings, because of their greater length, though here great differences exist. If rollers happen to get out of alignment they are as troublesome as rigid bearings are. In order to avoid this is the reason why in some designs the rollers are only one diameter long, while in others they are, though long, made of a flexible character to enable them to maintain contact by reason of their elasticity, and thus accommodate themselves to inequalities.

Another essential is the capacity of accommodation to resist axial thrust. The ordinary ball bearing will not do this. In the ball bearing used for shafting the thrust of the balls is only provided for radially. Lateral thrust must be received either in special thrust bearings, or by the common system of fixing the central bearing race in a series in its housing, leaving the others free to take slight lateral movements. This may not seem to be an ideal arrangement, but it is the only one available in ordinary designs.

The limits of inaccuracy now are cut very finely. Balls, rollers, races, are ground within tolerances that are measured within two or three ten-thousandths of an inch. The result is that all the balls or all the rollers take their equal shares of duty, which duty would be thrown on individuals under a coarser system of measurements. The life of the unit is thus prolonged through several years, and all parts of a size and class are strictly interchangeable. Some of the objections to the early ball and roller bearings have thus been removed by the improved systems of manufacture adopted. Advanced scientific methods have been brought in to control the workshop practice, both in regard to the selection of material and its treatment, which combine to ensure practically precise uniformity, so that balls do not flatten nor rollers get out of alignment during many years of service. The heat treatment adopted ensures the permanence of the dimensions and shapes imparted. By adopting a uniform heat treatment on a steel of uniform character, checked continually by Brinell or Shore hardness tests, practically identical results are secured in successive batches of products. The steels used, being good, are responsive to the treatment accorded them. Distortion and cracking are both avoided by this treatment, which imparts a highly toughened interior to balls, rollers and races, and a glass-hard surface penetrating to a small distance. A safe working load is combined with a high degree of resistance to crushing and with a high elastic limit.

The conditions under which bearings are to be installed are as highly important to remember when determining a choice as are the characters of the various designs of bearings themselves. Here comparisons are perhaps too often made between dissimilar conditions. With ideal shaft mountings, where support is good, and where readjustments have established permanence in the alignment of bearings, the ordinary swivel bearings, with brasses or Babbitt linings, are satisfactory enough to be retained. The substitution of ball or roller bearings for these would not be justified. Under contrary conditions a change may be advisable.

When a new factory is being equipped, that offers the most suitable occasion for the installation of a system of ball bearings. Many firms, therefore, adopt these now when laying out new shops. Then no difficulties arise in consequence of having to dismantle sections of the mountings in order to get the new bearings into position. For all ball bearings, being self-contained unjointed units, have to be slid endwise into position along the shaft on which they have to be fitted. This obligation requires the removal of whatever happens to obstruct the way, whether pulleys, gears, couplings or collars. Trouble may also occur because of the necessary fitting of the inner race to the shaft. When its bore is required to fit the shaft exactly this is frequently an unattainable ideal, because of slight variations which occur in the diameters of commercial shafting. To provide for these variations is the reason why an alternative method of fitting

Fig. 78.

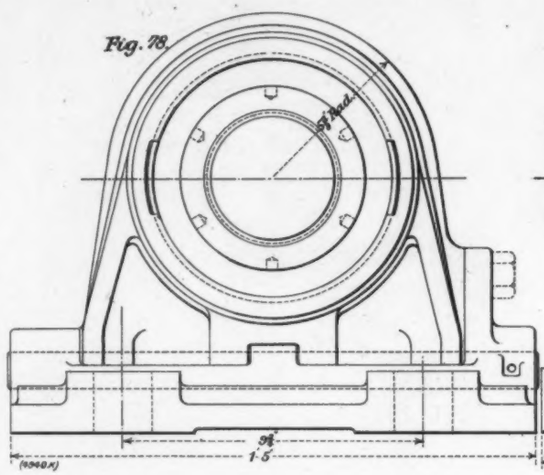


Fig. 79.

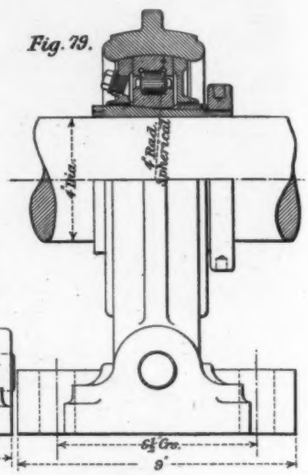


Fig. 80.

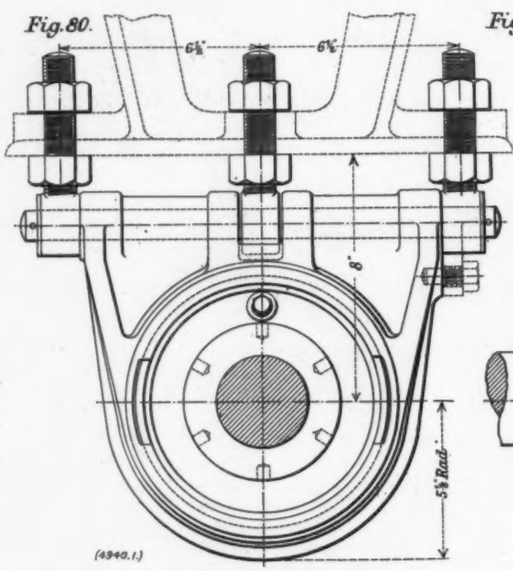


Fig. 81.

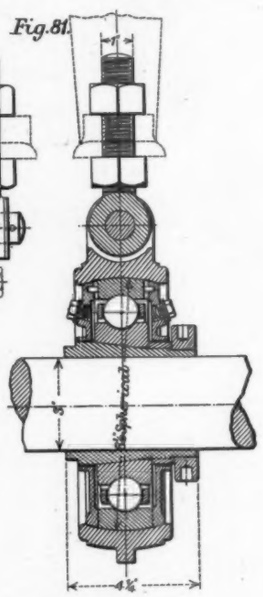


Fig. 82.

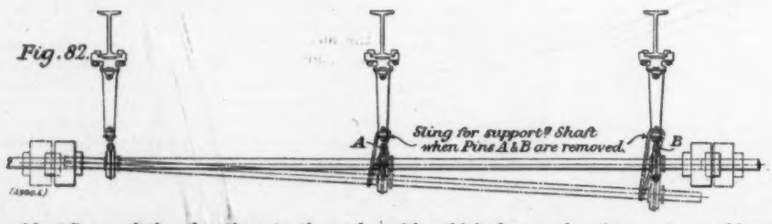
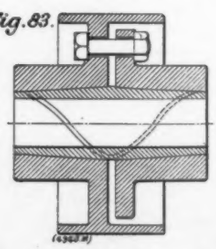


Fig. 83.



is offered by all manufacturers—that of tapered sleeves. Provided the sleeve does not work loose, and that it is made substantially, this is a satisfactory solution of shaft variations, but it does not dismiss the objection to the dismantling of pulleys and other fittings. For these and some other reasons the most favourable conditions for installation of ball bearings occur, as we have said, where entirely new shafting is in contemplation.

Notwithstanding these restrictions, the growth of popularity of the ball and roller bearings for line shafting is a remarkable fact. At an early period such bearings were valued chiefly because of their applications to very high class mechanisms of a light character, bicycles, automobile axles, dynamos and motor shafts, and to some light high-speed spindles and shafts. The bearings were believed to be too costly for shop shafting. Neither were ball bearings deemed suitable for this duty, but rather the roller bearings. And in these the difficulty of preserving alignment was believed to be an almost insuperable one. In consequence the swivel type of bearing of about three diameters long, with or without ring-oiling, remained the favourite, as indeed it still is in many shops. But, on the other hand, many of the recently constructed shops now instal the ball or the roller bearings for new shafting, undeterred by the greater initial outlay which they involve.

Ball journal bearings have become crystallised into one general design, that, namely, of balls retained in cages and running in concave races. Balls in contact without cages—the bicycle design—are unsuitable for the heavy loads that are imposed by shafting. The vee'd section of races with absolute point contact are ruled out for the same reason. Neither are thrust washers with flat faces suitable, but concave wearing surfaces are invariably employed in order to distribute the load, and to avoid the wearing of flats on the balls and the chipping and abrasion and fractures which result from the concentration of heavy pressures on minute surfaces.

The success of the ball bearings in their application to shaft driving is largely due to the adoption of a curvature to the races the section of which bears a relation to that of the balls. This strikes a mean between the flat race, which reduces friction, but is destructive to balls and races, and the concave race, which has exactly the same curvature as that of the balls, with, it is true, a better distribution of the load, but with much resulting friction. The present practice is to employ, instead, a curvature that lies somewhere between the two. This has been given as a radius that should not be more than 1.25 times the radius of the ball, while in some instances the best efficiency is obtained when the radius is as small as 1.02 times that of the ball. In a radial drive the radii of the inner and outer races should not be alike, but that of the inner one should be less than that of the outer one. This is adopted in races, but the groove is made deeper, and the net result is that about equal bearing surfaces are obtained in inner and outer races. Another aspect of the ball and roller bearings is this: A large proportion of length to diameter is not required, as it is in the plain bearings. It follows that less shaft length is used in bearings, and that the bearing fittings, brackets, housings, hangers, &c., are all of smaller dimensions, with less weight and cost.

An important change, which has been stereotyped in many ball and roller bearings, is the substitution of grease lubrication for that of oil. Once a day at least the oil-can was in demand to fill the oil-cups in the caps of the old rigid bearings. The waste oil dripped from the bearing, and a tray was necessary if mess was to be avoided. The ring-oiling marked a long step in advance. The grease used in the ball and roller bearings is better still. Once filled, the bearing will run for several months without attention, and there is no mess. There is no risk of bearings becoming overheated and scoring or seizing by neglect to oil them at the proper intervals. Occasionally it has happened that fires have been started by hot bearings smouldering in dust accumulations adjacent. From these risks the ball and roller bearings are free.

Fig. 84.

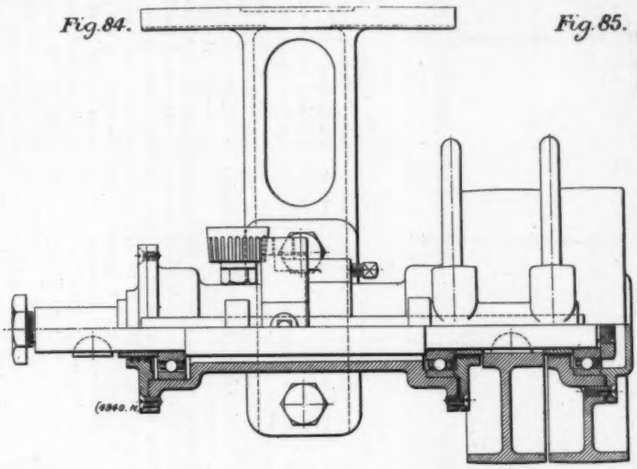


Fig. 85.

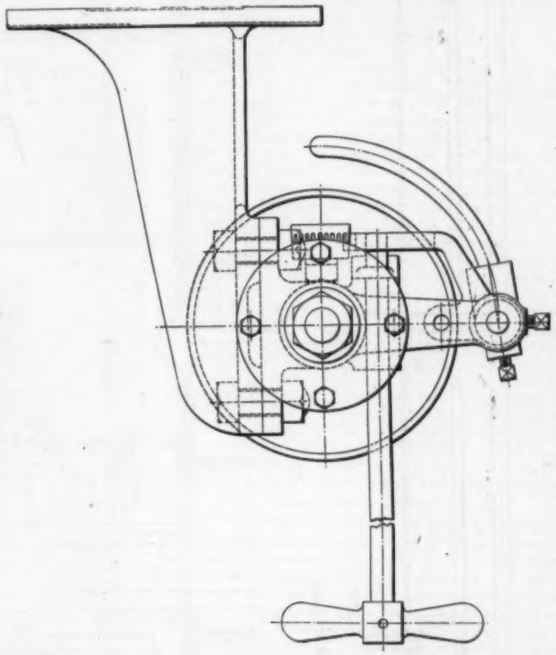
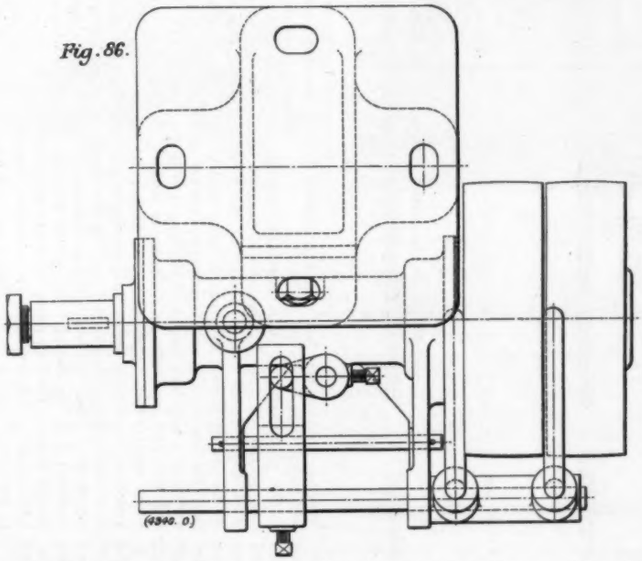


Fig. 86.



The "Hoffmann" ball and roller bearings, as designed for line-shafting, are shown in Figs. 78 to 81, the first design, shown in Figs. 78 and 79, being a roller bearing suitable for pedestals, and that in Figs. 80 and 81 a ball bearing suitable for hangers. A number of special features of this latter bearing call for detailed explanation. It is an adaptation of the firm's standard single-row ball journal bearings to meet the special requirements of line-shafting. The balls run in a cage or separator between the hardened steel rings. The inner race is clamped firmly to the shaft by means of a sleeve which revolves with it. The outer race, which is ground on its outer surface to a spherical form, fits into the main casting or housing, and immediately alongside of it, and turned on their outer periphery to conform to the spherical seating, are end-covers which retain grease and also prevent the entry of dirt. The ball cage or separator is made of solid-drawn gun-metal, and increased strength is claimed for it as compared with the more usual stamped cage. The maximum number of balls is fitted consistent with the strength of the cage. These balls are made of carbon-chrome steel, heat-treated, with the result that the interior is very tough and the surface glass-hard. They are ground to within one ten-thousandth of an inch of standard, both as to the spherical form and as to size, thus ensuring equal distribution of the load alike over the balls and their races. The races are of a mild carbon steel, also heat-treated to give these a tough body and a glass-hard surface.

Whilst for line-shafting work where the inner race must be passed over a long length of shafting it is necessary to clamp it by means of the adaptor sleeve above referred to, the firm recommend for ordinary short machine shafts a bearing with a straight inner race pressed firmly on the shaft and

Fig. 87.

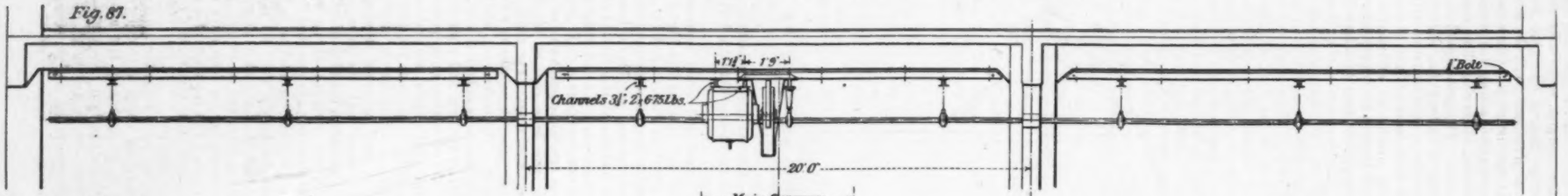


Fig. 88.

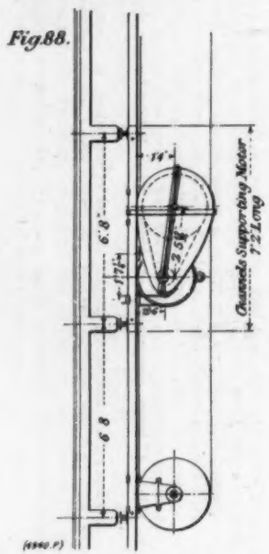
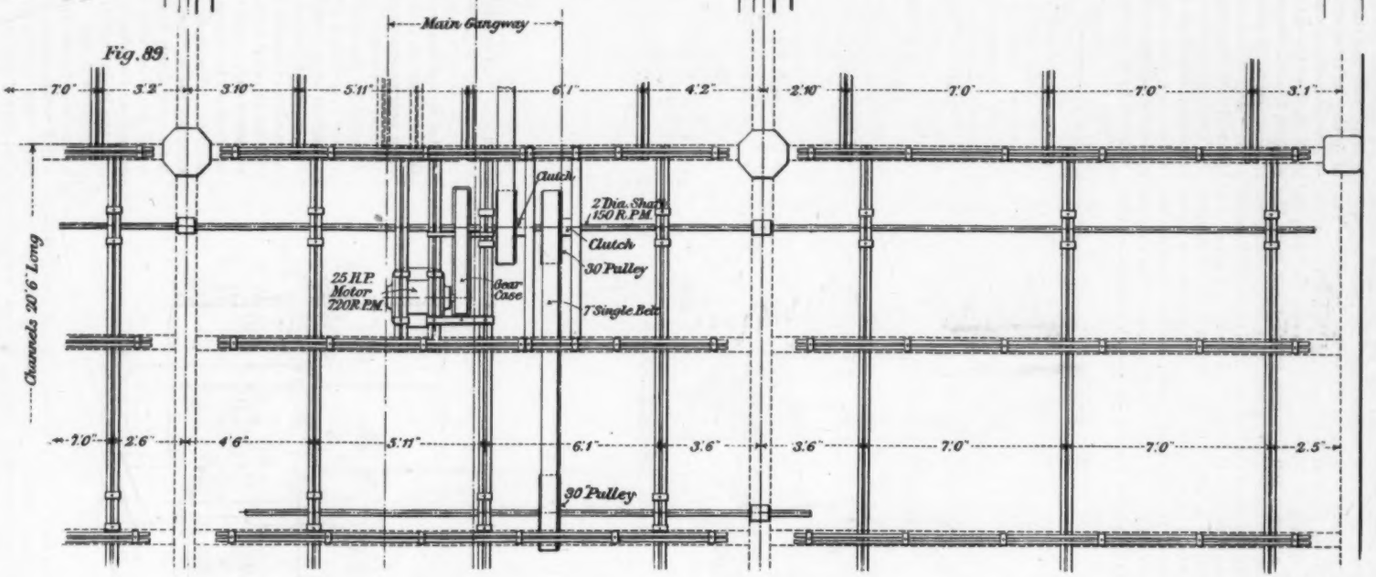


Fig. 89.



gripped between shoulders, as in the case of the countershaft fitting shown in Fig. 84. From Figs. 79 and 81 it will be seen that where the adaptor sleeve is used, when the sleeve is thrust into the inner race and the nut is pulled hard up, the effect is to clamp the shaft, sleeve and inner race together as one unit, giving complete rigidity.

The spherical form of the outer ring or race permits of the universal swivelling motion of the bearing, thus enabling it to align itself with the shaft. It should be noted that the covers swivel with the outer race and cannot therefore bind on the revolving parts, or gape open to admit dirt. These covers are bored to within 0.004 in. of the revolving pieces and are grooved as shown. This very fine clearance is always maintained, and consequently no dirt can get into the bearing.

The main housing is either a pedestal, as in Figs. 78 and 79, or a hanger, Figs. 80 and 81. In each case the lateral movement necessary to accommodate the expansion or contraction of the shaft resulting from variations in temperature is permitted by the housing carrying the ball bearing, rocking on an horizontal bolt.

The manufacturers claim that the bearings are very simple to erect. In the case of hangers being used, these should first be bolted to the brackets in the ordinary way, due regard being paid to the fact that one bearing only is locked to hold the shaft endways. In a long length of shafting it is preferable to select one lightly loaded near the centre. In those cases where bevel wheels or similar driving gear likely to cause a thrust load are employed some more adequate provision for carrying the thrust is necessary. After the bearings are attached to the brackets they can be lined up by the nuts on the hanger bolts. The two outer eye-bolts only should be clamped in the first instance, and when these are in position the bolts on the centre eye-bolt can be screwed up by hand and tightened simultaneously by means of two spanners. The bearing portion should now be taken down, which is readily done by extracting the transverse pin on which it rocks. The bearing part is threaded on to the shaft, the whole lot lifted into position and the transverse pin reinserted. Pedestals can be lined up in the usual way, and when this has been done the rocking-pin can be removed and the bearing part put in position on the shaft, as in the case of the hangers. When the bearings are finally put in position the sleeve should be clamped in such a position on the shaft that the housing is vertical. This clamping should be very securely done.

When ball bearings were first introduced for line-shafting engineers hesitated to adopt them because where the need for replacement arose the shaft had to be stripped of all pulleys in order to take off the old bearing and put on a new one. With the modern high-efficiency ball bearing, replacement is very rarely needed; when it is required the "Hoffmann" line-shaft bearing seems to be very simply changed.

Assuming that a length of shaft is supported in three bearings with a coupling outside each end bearing, as in Fig. 82, the coupling, the original position of which is shown by the full lines, is slackened. It is then driven on to the end of the short length of shaft, as indicated by the dotted lines. The particular coupling shown in the illustration, Fig. 83, is the Warden patent compression flange coupling, and this is very easily fixed or removed. If the bearing "A," Fig. 82, has to be exchanged, any pulleys between "A" and "B" must be stripped; the rope slings shown are fixed round the shaft and the brackets to take the weight, the split pins and washers are removed from the horizontal bolts, and these latter are driven out of the housings—this is readily done by light blows from a hammer. The sleeves are then loosened and the bearings are ready to strip off the shaft. It will be noticed that the bearing at the other or left-hand end of the shaft is not moved, nor is the shaft lowered to the floor. The swivelling feature of the bearing to the left is utilised to rock the shaft to the position shown by the dotted lines, so that bearings "A" and "B" can be removed. When the new bearing has been fitted at "A" the reverse of the preceding operations takes place. The advantage of the method just described is that

THE "PETERS" HIGH-PURCHASE GRAB.

CONSTRUCTED BY MESSRS. STOTHERT AND PITT, LIMITED, BATH.

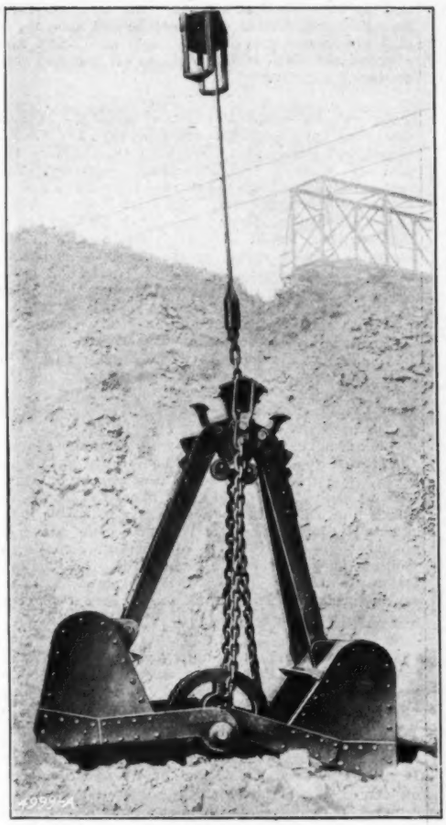


FIG. 1.

FIG. 2.

much time is saved and that the vertical adjustments of the three suspension bolts are not interfered with in any way.

For shafts above 3½ in. in diameter roller bearings are fitted. These are interchangeable with the ball bearings and have all their advantages, with an increased load-carrying capacity. The rollers in these bearings are made from the same quality of steel as the balls and are guaranteed to be within 0.0002 in. of standard diameter and 0.0004 in. of length. The ends are square, and the rollers are of the same nominal diameter as length. They run (in the line-shaft type of bearing) in channels or grooves in both inner and outer races. Views of one of these bearings are given in Figs. 78 and 79, page 146, already referred to.

The standard "Hoffmann" ball-bearing light countershaft is shown by Figs. 84 to 86, as designed for belts ranging from 1¼ in. to 2 in. It embodies a shaft, of 1 in. diameter, and the dimensions are generally alike, the diameters and widths of the pulleys alone being varied. This countershaft is very readily fitted, as it has only one bracket instead of two. The countershaft is mounted on two ball journal bearings of the usual type. The one to the right is rigidly fixed in its housing by the clamping of its outer race by means of the end cap. The one to the left is free to slide with the expansive movement of the shaft, its outer race having lateral clearances. The loose pulley runs on a single row of balls. The striking gear is slid by the handle below, which, through the lever and the solid bar seen in Fig. 86, moves the belt fork along. This countershaft is eminently suitable for light machine tools.

A lay-out of Hoffmann ball bearings in one of the recently equipped modern factories is illustrated by the drawings, Figs. 87 to 89, page 148. These show the general scheme adopted, the details of the bearings and their methods of attachment being those which have been given in the drawings preceding.

The bearings are supported by a grillage of crossing channels, which are bolted to beams of reinforced concrete beneath a concrete floor. The upper series of channels measure 3 in. by 1½ in. in section. The lower series, to which the hangers are bolted, are of 3½ in. by 2 in. section. The upper channels are 17 ft. 8 in. long, the lower ones are 20 ft. long. They are set back to back with 1 in. of space between, through which the bolts pass that secure them in the concrete. These bolts are 8 in. long, ½ in. diameter, screwed 1½ in. long. They have T-heads, are ⅞ in. square under the head, and are fitted with Grover spring washers.

The channels are bolted together through hardwood packings, 3 in. by 3 in. by 1 in., which occupy the spaces between the backs of the channels. The bolts are 2½ in. long, with hexagon heads and nuts, and one plain and one Grover spring washer. The centres of the bearings are variously spaced, as shown in the plan, Fig. 89, from about 6 ft. to 7 ft. The hanger brackets are each carried by two ¾-in. bolts passing between the channels, which bolts are 6½ in. long, screwed to 1½ in. with hexagon heads and nuts and Grover washers. The line shafts are 2 in. in diameter and make 150 r.p.m. A 25-h.p. motor, running at 720 r.p.m., drives them through reduction gears with a chain connection from a 19-toothed pinion on the motor to one of 90 teeth on the shaft. From this shaft the one on the opposite side of the shop is driven by a 7-in. single belt over 30-in. pulleys. Channels are provided to carry the motor, and others for the gear-case, with suitable bolts, as shown in the drawings.

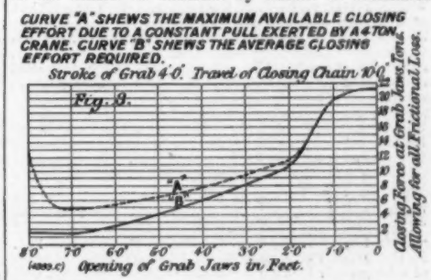
PORTABLE TRENCH PUMP SET.

ON page 145 we illustrate a portable trench pump set, comprising an Austin motor lorry, a four-cylinder petrol engine driving an electric generator, two electric motors direct-coupled to rotary pumps, hose suction and delivery pipes, and two reels of armoured conductors. The pumps are carried on adjustable supports with broad feet, and can be fixed at a very considerable distance from the generator on the lorry, so that the latter may not be too much exposed to shell fire. They are capable of dealing with considerable quantities of water, and in some situations will add very greatly to the comfort of the troops. Unfortunately there are many positions, especially towards the western end of our line, in which the trenches form natural sumps for the collection of subsoil water and there is no fall to carry off the delivery from the pumps, which only adds to the general sloppiness of the neighbourhood, and gradually finds its way back. Fortunately this condition of affairs is not universal, and even if only a temporary drying of the trenches were effected, it would be welcomed by all that have to guard them.

The motor lorry produced by the Austin Motor Company, Limited, of Northfield, Birmingham, has lately undergone various modifications, the result of experience gained in the field. The main bearing bolts are now carried right through from the top of the crankcase; a flexible oil pipe is fitted between the oil-tank and the engine, to prevent rupture due to vibration; an improved type of clutch-coupling centre-bolt is fitted, and the frictional surface of the clutch has been increased from 2½ in. to 3 in. in width. A stronger differential box is fitted, and the gears are in nickel-chrome steel, in place of mild case-hardened steel; roller bearings are used in place of ball bearings for the pinion shaft at the rear axle. In many other parts minor but important alterations have been made, and the parts which have shown distress under the searching conditions found at the Front have been redesigned on more liberal lines. The Austin Company is now permitted to take orders from private users, particularly if they are engaged on work of national importance.

THE "PETERS" HIGH-PURCHASE GRAB.

ONE effect of the great scarcity of labour throughout the country has been to extend widely the use of grabs for handling various classes of material, and it is in this connection we illustrate on this page the "Peters" patent high-purchase grab, manufactured by Messrs. Stothert and Pitt, Limited, of Bath. Although this patent grab has only been on the market for a comparatively short period, it has already attracted wide-spread attention on account of its many advantages. It is the result of many years' experience in the handling of all classes of material by means of automatic appliances. It is of simple design and contains very few mechanical parts. Its efficiency is high owing to the simplicity of operation and the peculiar characteristic of the cam-shape barrel and eccentric shaft. In many similar appliances a constant purchase is effected by means of several falls of chain passing around pulleys, but in the "Peters" type a special cam-shape barrel is used, which imparts to the grab a gradually-increasing closing force as the jaws close. By this means useless expenditure of energy and travel of closing chain or rope is avoided, as the closing force exactly follows the work to be done throughout the stroke, commencing by gathering the material, which gradually increases in weight, and finally forcing it into the bucket and crushing through any obstacles between the jaws. Fig. 3 is a diagram showing the closing force of a 4-ton grab throughout its stroke. As this affects the speed of operation and the work done by the crane, it may be as well to emphasise this fact by stating that for a grab with, say, a 4-ft. stroke and a purchase of 6 to 1, the amount of chain or rope withdrawn to close the grab is reduced from 24 to 10 ft., or from two-fifths to one-third of the length required for a grab with multiple purchase gear, the advantage being even more noticeable with the larger grabs.


CURVE "A" SHEWS THE MAXIMUM AVAILABLE CLOSING EFFORT DUE TO A CONSTANT PULL EXERTED BY A 4 TON CRANE. CURVE "B" SHEWS THE AVERAGE CLOSING EFFORT REQUIRED.
Stroke of Grab 4'0". Travel of Closing Chain 10'0"
Fig. 3.
A
B
80 70 60 50 40 30 20 10 0
(Ass.c) Opening of Grab Jaws in Feet.
Closing Force at Grab Jaws Tons. Allowing for all Frictional Loss.

Owing to the few moving parts the grab opens and

shuts smartly, and friction, with consequent wear, is almost eliminated. It will be seen from the illustration that the grab has no special crosshead, the whole of the mechanism for the single, double or treble chain or rope grab being contained within the specially designed connecting or closing rods, which form a hinged A frame, thus avoiding all parallel motion, cross-binding, and consequent wear and tear. With this arrangement of framing the grab is exceedingly strong and light. The closing barrel does not make a complete revolution, and in the act of closing the barrel revolves quite clear of the contents of the grab. The eccentricity of the barrel is also useful for overhauling the lifting barrel of the crane, obviating the necessity of adding useless weight, which is inevitable when multiple purchases are used. Another important feature is that the centre of gravity is very low, the heaviest part being the eccentric barrel; it follows that the grab has little tendency to overturn even when working on a steep incline. The space occupied by the grab is remarkably small, and as no ball or similar device is necessary on the chain the grab can be worked close up to the jib head of a crane.

The grabs are designed to work either with single, double or treble chain or wire rope, and are adapted to all conditions of working and every kind of material, for excavating, dredging, &c. They can be operated by jib crane, overhead travellers or transporters. In the double and treble rope grabs the opening rope can be controlled either by a second barrel in the crane, with suitable frictional drive, or by the "Peters" automatic spring drum, which can be fixed to any suitable part of the crane or hoist. Simple automatic dumping gear is fitted to the single-chain grab when required, which enables the grab to be worked independently of its suspender on the ground, and also enables the grab to be freed when entangled or held by suction under water, thereby greatly enhancing the duty of the grabbing.

The "Peters" grab has been in great demand for handling iron ore, a material for which it is eminently suited; and grabs of this type can be found in many of the principal ports of the country employed on this work. A considerable number are in operation in the Middlesbrough district, and their satisfactory handling of iron ore may be gauged by the fact that, from one Middlesbrough firm alone, Messrs. Stothert and Pitt have already received four repeat orders. At the present juncture we understand that the makers have a considerable number of these patent high-purchase grabs in course of construction; and in many cases the Ministry of Munitions is affording special facilities for their manufacture, in view of the importance of dealing with raw materials in the most expeditious manner possible.

Glass Grinding and Polishing.—With the object of enabling foremen and operatives of glass-grinding departments of optical instrument works to hear the paper on "Glass Grinding and Polishing," by Mr. James W. French, B.Sc., of Glasgow, which was read and discussed at the last meeting of the Optical Society, arrangements have been made for it to be repeated, with all the illustrative lantern slides, at the Northampton Polytechnic Institute, St. John-street, Clerkenwell, on Friday, February 23, at 8 p.m. Tickets may be obtained from the secretary, at 39, Victoria-street, Westminster.

Lubricating Oils.—At the January meeting of the Diesel Engine Users' Association a paper on the "Chemistry and Examination of Lubricating Oils" was read by Mr. Elliott A. Evans, F.C.S., A.M.Inst.P.T. In the paper the author states that the differentiation of mineral oils is often a matter of great difficulty, but, speaking generally, one may obtain some criterion as to the origin of an oil by its specific gravity, for example, Texas oils have a specific gravity ranging about 0.950, Californian oils 0.930, and Pennsylvanian oils 0.876 to 0.910. Some Californian oils are now on the market but they cannot be recommended universally as lubricants. Their viscosity diminishes rapidly with rise of temperature. For some purposes they may be blended with Pennsylvanian oils, but where a good lubricating oil is desired Californian oils should not be used. The Texas oils are used to a considerable extent for many purposes, but owing to the fact that they are chiefly composed of the series $C_n H_{2n} - 2$ and $C_n H_{2n} - 4$, they are very liable to decompose at elevated temperatures, and perhaps at high pressures. The suggestion that a compound oil should be used as a lubricant for air compressors must be condemned, and although the author recommends a mineral oil consisting of the series $C_n H_{2n} + 2$, nothing has been said as to which members of the series should be used. It is of little importance to ascertain which particular hydrocarbons of the series are present in the oil, because if we know the flash-point and the viscosity of the oil we know approximately which members are present, which is in general sufficient for our purpose. Mr. Evans expresses the opinion that an oil with a specific viscosity of about 70 (water = 1), or in seconds 2,500, and a closed flash-point of about 400 deg. F. can be safely used if the temperature of the compressor be carefully regulated. The discussion on Mr. Evans's very interesting paper is to be taken at the next meeting of the association.

INDUSTRIAL NOTES.

In the report of their proceedings during the past year the Employers' Parliamentary Council express the opinion that when the time comes for taking stock of the nation's industrial resources, in view of the universal competition which will rule the markets of the world, it will be found that any return—even on a small scale—to the conditions which governed national production in the period before the war would be disastrous and possibly fatal to British interests, both at home and abroad. It may, say the Council, be assumed as extremely unlikely that the systematic restriction of output which prevailed before the war, and is unhappily still existent, will ever again find favour in this country outside the ranks of the labour unions. It is worthy of note that this system, which was found to be such a grave menace to the success of British arms in the field, and was vigorously denounced by those responsible for the conduct of the war, had been universally declared by the labour unions not to exist. It is permissible to hope that even among labour unionists, when once the stern realities which have yet to present themselves become generally appreciated, the lesson of the past will serve as a warning against future folly, and wise counsels will prevail where formerly a wholly mistaken and mischievous policy was pursued.

The demand that after the war labour shall take a larger share of the profits of industry—a demand that has been endorsed by several members of the Government, and with which sympathy has been expressed in many influential quarters—is, in the opinion of the Council, one to which no reasonable exception can be taken, provided that labour, earnestly and wholeheartedly, performs its part in the general scheme of production, and thus establishes a good title to the claim for greater remuneration. A high standard of production can be maintained only if the energies of capital and labour alike are exerted to their utmost capacity. Whatever the conditions under which various industries are conducted in the future, whether by systems of co-partnership, profit-sharing, or wages, the effort everywhere will have to be of a generally sympathetic and high-spirited character if all concerned are to benefit in the shape of increased gains. It has been frequently suggested of late that the war has broken down class barriers, and that the old element of suspicion—which, it is alleged, pervaded the relations between rich and poor, capital and labour—will have disappeared when the ordinary life of the nation is resumed. If this should prove so, and all classes unite in the common aim of ensuring the nation's prosperity and progress, there will be no room for strife and strikes, but each and all will be animated by mutual trust, and strive for the best results which friendly combination and co-operation can hope to achieve.

In the unavoidable absence of the President, Mr. G. H. Roberts, M.P., Parliamentary Secretary to the Board of Trade, received last week a large and influential deputation representing the cotton trade. In the course of the interview it was stated that at a meeting held in Manchester last December the following resolutions, among others, were passed: ". . . That it was essential for the future prosperity of this country, and also for the welfare of the Colonies, that cotton growing should be developed as rapidly as possible in all suitable parts of the Empire. That the authorised irrigation works for the development of the Gezira Plain should be pushed on with the least possible delay. That immediate steps should be taken both to improve the quality and to increase the quantity of Indian cotton. . . ." Mr. Edward Judson, of the Amalgamated Association of Operative Cotton Spinners; Mr. William Mullin, of the Amalgamated Association of Card and Blowing Room Operatives' and Mr. Joseph Cross, of the Amalgamated Weavers' Association, urged the importance of the subject to the cotton operatives of this country, who had liberally subscribed to the funds of the British Cotton Growing Association in order to promote the growing of cotton within the Empire. In the course of his reply Mr. Roberts said he considered that those products which could be produced in this country or in the British Empire should be so produced. On the broad general principles, therefore, he found himself in cordial agreement with the aims which had been put forward. He was very glad to observe a recognition of the community of interests between the employers and the employed in the cotton industry, which he regarded as a very good omen.

Following upon our note on page 125 *ante*, we are able to state that the Lancashire cotton spinners have now accepted the employers' offer of a 10 per cent. advance in wages. The offer has been accepted subject to either side being at liberty to apply for an alteration at the expiration of six months. The advance comes into operation on the pay-days of the present week.

Mr. John Hodge, the Minister of Labour, speaking at Southall last Friday, stated that one of the things of which the country should be proud was the manner in which British iron and steel manufacturers had risen to the occasion. We were producing over 50 per cent. more steel than we did before the war. That showed that when the need came upon us we could organise, and his hope was that when the war was over those lessons of organisation would not be lost upon us, so that when peace prevailed we might once again take a prominent place in the world as an iron and steel producing country.

Not only have trade unionists obtained the Department they have been clamouring for, says *The Federationist*, but labour men have been appointed to the post of Minister and Permanent Secretary. The success or failure of this Department is entirely a matter for the Labour movement. Mr. John Hodge and Mr. David Shackleton will undoubtedly do all that lies in their power; but if they are confronted with the hostility, open or veiled, or the apathetic negligence of the Labour movement, all their efforts will be in vain. It is no use the Labour movement demanding a Ministry and officials unless it retains its association with the Department and a certain amount of *camaraderie* with the officials. One Labour organisation, adds *The Federationist*, which had been asked to place its views before the Labour Ministry on the premium-bonus system, refused to take any action, though it knew that the employers had already decided to approach the Ministry. It may be true that the organisation itself, while declaiming generally against the premium-bonus system, had not secured unanimity on the subject among its constituent parts; or, what is more likely, that it had never taken the trouble to obtain and collate the facts necessary to enable it to present a considered case. Whatever cause prevents co-operation—and through co-operation some controlling influence—should be removed at once. Neither jealousy nor disappointment should operate. If there are any signs of these the rank and file should take the matter up immediately.

Mr. R. Wilkie, M.P., secretary of the Shipwrights' Society, and Mr. John Hill, secretary of the Boilermakers' Society, have been appointed by the Shipping Controller to advise his Department on labour questions.

Earnings of American steel companies in 1916 exceeded all expectations, says *The Iron Age*, New York. It was a record year for wiping out deferred dividends on cumulative dividend stocks, as well as for the declaration of extra distributions of profits. In this latter respect, however, steel companies have been decidedly conservative. Mindful of the lean years sure to come, they have preserved substantial surpluses, and are thus facing the future with far less apprehension than ever before. Labour has shared in the prosperity of the year. Three times in the twelvemonth were wages advanced by the steel manufacturers, each time 10 per cent., while workmen paid on a sliding-scale basis were steadily benefited by the rising prices of the products they made. It is safe to say that never before, in this or in any other country, were iron and steel workers in receipt of such incomes from their daily toil as the workmen of the United States in 1916. Although prices have long been regarded as dangerously high, the belief of some in the steel trade is that when readjustments come they will be gradual and not so violent as to cause disaster. On the other hand, there are those who emphasise the possibility of radical changes in prices after the war, and also of the competition of foreign-made steel products in the United States markets.

With a view to facilitate industrial activity on commercial lines throughout France as soon as possible after peace is declared, a Bill has been drafted providing for the taking of a census of all the existing machinery in the country. Every French works and factory, large and small, will be compelled to send in returns of the machinery it owns. The returns are to be centralised at the Paris Ministerial Departments, and are destined to form a detailed catalogue of the means of production available in the country. They will facilitate the rapid distribution of work to be carried out, and also the rapid employment of the men returning from the battlefield.

A special committee of the Sheffield City Council has recommended the taking of steps for the formation and control of an Industrial Development Department. The Department is to act with an advisory committee consisting of representatives of the Cutlers' Company, the Chamber of Commerce, the University, the Engineering Trades Employers' Association, the Cutlery Manufacturers' Association, the Master Silversmiths' Association, the two Trade Councils, and the Society of Architects and Surveyors. The committee will

watch over and promote the trade, industry, development and general prosperity of the city; promote the establishment of manufactories, trades, works and railway extensions; make inquiries as to land available for such establishments, the selling or leasing terms, and to assist persons to obtain such land on the best terms. Its other duties are to include dealing with all matters relating to the advertising of the city, housing, travelling facilities, &c. The cost of the Department will at first be defrayed out of the profits of the tramways undertaking.

The Engineering Employers' Federation and the allied engineering unions communicated last week to the executive councils of the engineering trade unions the following temporary procedure for the adjustment of war wages questions:—

"It is agreed that, having regard to the special circumstances of the war, the following shall be the principles upon which wages changes shall be arranged for the period of the war:—

"1. That existing agreements or practice under which applications for general alterations in wages are dealt with shall to that extent be suspended until the termination of the war or for such further period as may be agreed upon by the parties thereto. This shall not refer to agreements or practice whereby the wages of any trades in any district or department rise or fall with the fluctuations in another district or industry not covered by this agreement. Nor shall it prevent the unions bringing forward for special consideration at the hearings referred to in paragraph 2 (*a*) the case of any district in which they claim that the rates of wages are unduly low, or that the total amount of war advance is not adequate. On the other hand, the Federation shall be entitled to bring forward for similar consideration any special cases they desire.

"2. During such period of suspension the following procedure shall be observed, provided the consent of the Committee on Production is obtained:—

"(*a*) The Committee on Production shall, in the months of February, June and October, after hearing parties, consider what general alteration in wages, if any, is warranted by the abnormal conditions then existing and due to the war.

"(*b*) The award of the Committee on Production shall be an award under the Munitions of War Acts, and shall be of national application to all federated firms in the branch of trade concerned.

'(*c*) The first award shall take effect in all districts on the first full pay in April, and the altered rate shall continue until amended by a further award in accordance with the provisions hereof. Subsequent awards shall specify the date upon which the alteration awarded shall take effect."

It is expected that the agreement will be completed within the next few days, and that the first proceedings under the new arrangement will be taken before the end of the month. Attached to the agreement is the following clause:—

"The Engineering Employers' Federation and the unions whose signatures are appended hereto recommend to His Majesty's Government that arrangements should be made whereby all employers in the trade or trades affected should be subject to the awards which may be made by the Committee on Production, in virtue of the agreement hereto attached."

We read in the *Manchester Guardian* that Mr. Tom Fox, in an address on capital and labour, delivered at the Manchester Athenæum on Friday last, said that the present great upheaval had given this country a rude shock. It was now generally admitted that if Germany had gone on quietly developing her industries and commerce for another 25 years, as she had done in the past quarter of a century, she would have accomplished all she desired without going to war. It was essential, therefore, that we should now take stock carefully of our industrial position. Capital and labour in Great Britain had developed two separate interests. This must be changed. The very existence of the Empire, let alone its prosperity, depended on it. Unhesitatingly he said to the captains of industry that if the workers of the country were expected to put more energy, brain and initiative into their work, the results of that extra energy, brain and initiative must be secured to them.

To keep our industrial position in the world, Mr. Fox continued, we must not only have an increased output, but better organisation in our workshops, a drawing closer together of employer and employee, and an eradication of that jealousy and suspicion which had their roots deep down in the ignorance each had of the other. He suggested that there should be associations of employers, which would do their best to see that all employers "played the game," and associations of workers who, with the co-operation of the employers, would try to induce all workers to do likewise, so that all could work together for the common good.

It would be wise, too, if employers set up committees of workers representing each department in order both to give and receive information. Many of the objectionable things that took place in workshops, he added, were not due to the heads of those departments, but to unfit people appointed by them. Then if difficulties arose which could not be settled between the committees and the firms, appeal could be made to the associations. The adoption of the canteen system in workshops, giving workers the opportunity to get good, well-cooked food at cost prices, would recoup employers many times over by the increased efficiency of the workpeople.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting of the Physical Society of London, held on Friday, January 26, Professor C. V. Boys, F.R.S., president, in the chair, a paper, entitled "*A Clock of Precision*," was read by Mr. C. O. Bartrum.

The principal feature of the author's arrangement is the employment of a "slave" clock to do the greater part of the work, leaving the master pendulum no function beyond that of controlling the rate of the other. The master pendulum swings freely except for a short period (about one-fifth of a second) every minute, during which it receives an impulse from a small falling pallet electromagnetically released by the slave clock. At the end of its fall the pallet closes a second circuit and is restored to its initial position. These two electric circuits also energise parts of the mechanism in the slave clock, by which the latter is kept in time with the master pendulum. The lagging of correction behind error, with the resulting periodic fluctuation in the rate, is reduced almost to the vanishing point by the introduction of a "negative backlash" in the control mechanism.

The paper contains a mathematical discussion of the best working conditions and of the possible magnitude of errors which might arise from various causes.

Discussion.—The president said the subject was one in which he had the keenest personal interest, and he congratulated the author on the efficient way he had dealt with the problem and the successful result which he had obtained. Of the numerous elements which went to make up the clock, that which he thought he most admired was the device for abolishing "hunting" by means of negative backlash. With regard to the most suitable arc of vibration, it was possible that this could best be determined experimentally, as it had been with escapement clocks, for here, as elsewhere, there are the counteracting advantages of improving isochronism with reduction of arc and improving stability of amplitude with increase of arc. Such tests could only be made usefully under the most perfect conditions for the master pendulum. As in the case of all new inventions, it was certain that the few people who were interested in the production of the perfect clock would immediately see other ways of doing the same thing. There was no merit in this comparable with the original invention, but some of the modifications might be useful. He had himself found it impossible to avoid thinking of devices alternative to some of those employed by Mr. Bartrum.

[Professor Boys then proceeded to sketch out an alternative method of maintaining isochronism between the master pendulum and the slave clock without giving the pendulum of the latter as much work to do. A full account of his contribution will appear in the Proceedings.]

Mr. Duddell said that at the Paris Observatory there was a standard seconds pendulum in a chamber 60 ft. below the surface of the ground. The temperature was constant, and there were no pressure variations, as the pendulum was in a vacuum. It was driven electrically, and maintained a perfectly constant rate, requiring no attention whatever. It gave a signal in a telephone every second.

A paper on "*The Effect of Water Vapour in the Atmosphere on the Propagation of Electromagnetic Waves*," by Dr. Frederick Schwers, was taken as read, on account of the lateness of the hour.

The author discusses the probable influence of moisture in the atmosphere on the refraction of electromagnetic waves round the earth's surface. The conclusion of Kiebitz that the presence of moisture does not affect the dielectric constant by more than 10 per cent. is shown to be erroneous, being based on the assumption that the Clausius-Mossoti formula, $\frac{k-1}{k+2}\cdot\frac{1}{d}$ = constant, holds when passing from the liquid to the gaseous state. Examples are quoted to show that this law fails in many cases, especially where the dielectric constant is high in the liquid state.

In the absence of more accurate data for ordinary temperatures the author prefers to assume a value for the dielectric constant of water vapour obtained by extrapolating the results found by Baedeker for higher temperatures. The extrapolated value is almost certainly too low.

From this result, and the average conditions of the atmosphere over the ocean with regard to temperature gradient, &c., deduced from meteorological data, it is shown that the lowest layers of the atmosphere (1,000 to 1,500 m. approximately in depth) refract electromagnetic waves towards the earth, so that the greater part of the space waves will reach the receiver, contrary to the conclusion of Kiebitz.

Discussion.—Dr. C. Chree (communicated remarks): The author, presumably unaware of their existence, does not refer to the somewhat numerous upper air data which have been published in this country by the Meteorological Office. A study of these data as to the temperature gradients would, I think, have proved useful. Inversions are not confined to the lowest layers, but in these layers they are exceptional, and do not suffice to reduce the average temperature gradient to such low values as the author has taken for the first and second kilometres. For these, 5 or 6 deg. per kilometre would not have been too high, especially for tropical regions. If the empirical exponential formula for vapour pressure be assumed, the pressure at any given height varies directly with that at ground-level, and so in temperate latitudes is much lower in winter than in summer. It thus seems rather a fundamental point whether wireless phenomena in temperate latitudes show a marked annual variation corresponding with that of vapour pressure at ground-level.

PERSONAL.—The Beldam Packing and Rubber Company, Limited, are removing to more commodious offices, and the new address, on and after February 19, will be 29, Gracechurch-street, London, E.C.

THE SANDWICH SYSTEM OF TRAINING FOR ENGINEERS.—The University of Bristol has arranged with 20 large engineering firms to receive their students on the sandwich system. The whole course occupies five years, including three periods in the works and three in the college. Application should be made to the dean.

STANDARD SPECIFICATION FOR CARGO-STEAMER ENGINES: ERRATUM.—In reproducing the paper on this subject in last week's issue there was a misprint on page 128, column 1, 24 lines from the bottom. The formula for the diameter of valve spindle is given as

$$\frac{\text{diameter of piston rod in gland}}{2} \times \tfrac{1}{4} \text{ in.}$$

This should be $+ \frac{1}{2}$ in.

REGISTRATION OF BUSINESS NAMES.—The registration of business names under the Act of 1916 will commence on Thursday, the 22nd inst. Forms can be obtained at the principal post offices gratis, and when filled up must have affixed to them a 5*s.* adhesive stamp and be returned to Mr. Bernard Mallet, Registrar of Business Names, 59, Russell-square, London. There are separate, differently coloured forms for individuals, firms, corporations and agents.

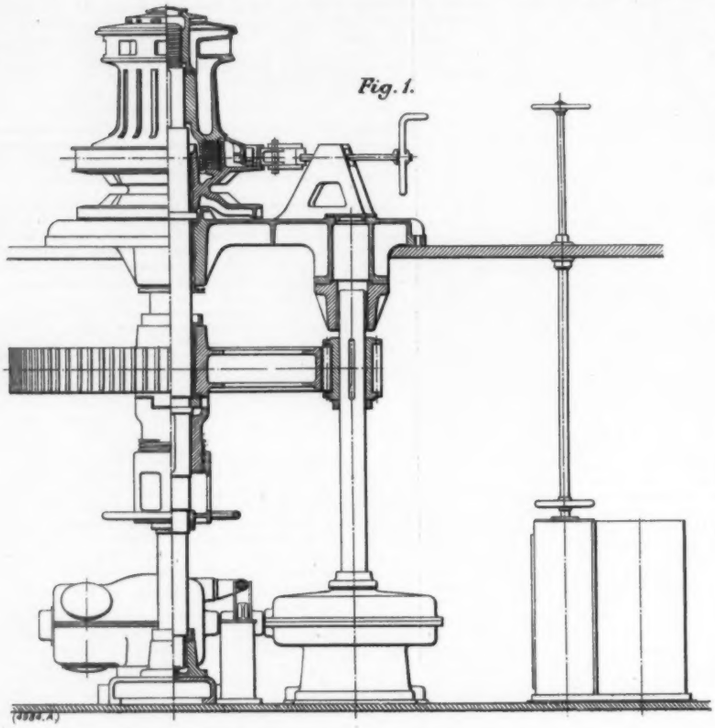
RADIOTELEGRAPHY.—The *Electrical World*, New York, makes a vehement protest against restrictions on wireless telegraphy in peace times. Progress in America has, it claims, been particularly rapid owing to the fact that the art has not, in the States, been constituted a Government monopoly. Even in Europe the progress made has been due to individuals and organisations unhampered by Government restrictions. The International Convention of London has, it declares, already hindered the industrial development of the system in the States, owing to the limited range of wave-lengths to which civilian experimenters are restricted. Complaint is further made that a Bill now before Congress will give the military authorities free entrance in commercial radiography and also increase their powers of regulation and restriction.

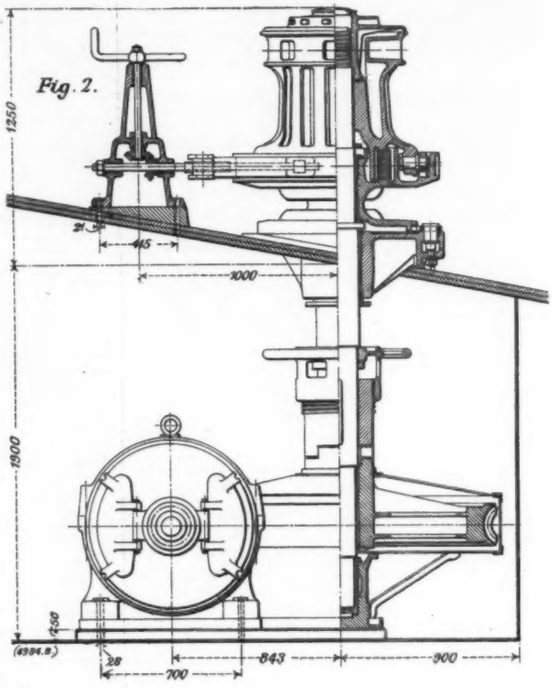
A LARGE ELECTRIC POWER STATION.—The Essex station of the Public Service Electric Company of New Jersey is described in a recent issue of the *Electrical World*. The station is intended, when completed, to contain plant with an aggregate rating of 200,000 k.v.a., but in the first instance two 25,000-k.v.a. units are to be installed. Special attention has been paid to reducing labour of every kind, and automatic gear has been fitted extensively, so that whatever emergency may arise will be met with little or no direct intervention by the station attendants. The coal plant comprises machinery for unloading the fuel from the cars, for crushing it to uniform size, and conveying it to the bunkers. The boilers are set high, so that there is ample space in the basement for ash-handling plant. The turbine-room is fitted with a 100-ton steam crane. The switch-house is six stories high, containing on the one side all the high-tension equipment and on the other the controlling rooms.

COMMITTEE ON IRON AND STEEL INDUSTRIES.—This committee expects to conclude the hearing of evidence within a few weeks from this date. Associations or individuals wishing to give evidence are requested to communicate with the secretary, Mr. C. Roland Woods, 6, Whitehall-gardens, S.W. The subjects of inquiry are:—(1) The extent and area of trade, and capital normally employed. (2) The dependency upon resources external to this country for supplies of material and plant. (3) Labour relations, labour restrictions (if any), and comparative conditions in the industry. (4) British methods of conducting foreign business contrasted with foreign methods of conducting export business. (5) The effects of manufacturing and commercial co-operation upon trade at home and abroad. (6) The extent to which British industry is adversely affected, whether as regards (*a*) the retention of business hitherto or previously secured, or (*b*) its capacity for expansion, by the existence of foreign tariffs, preferential arrangements, bounties, subsidies, or special facilities granted by foreign Governments, railways or trade combinations, to their manufacturers or exporters; and what, in your opinion, is the remedy. (7) Terms of payment and of credit. (8) Technical education, skill, and nature of employees. (9) The effect, if any, of wayleaves and mining or other royalties upon the industry, either as regards home or export trade. (10) The effect, if any, of railway and shipping rates upon the industry as regards home or export trade. (11) General information.

ELECTRICALLY-DRIVEN CAPSTANS FOR THE BRAZILIAN NAVY.

CONSTRUCTED BY THE OFFICINE ELETTRO-MECCANICHE, ENGINEERS, RIVAROLO-LIGURE, ITALY.





We illustrate in Figs. 1 to 3 on the present page two electrically-driven capstans for use on board ship, designed and built in a department of the Officine Elettro-Meccaniche, Rivarolo-Ligure, which has been specially set apart for the construction of such electric naval gear. The salvage ship Ceara, of the Brazilian Navy, which we described in preceding issues (Engineering, vol. ci, pages 180, 569 and 613), has two electric capstans built by this Italian firm. These capstans, which have been submitted to very severe tests and have proved most successful, are designed for a 51 mm. (2 in.) anchor chain and a pull of 9 tons at a speed of 16 ft. per minute, and a maximum pull of 25 tons. The electric motors are of the compound type, for a current pressure of 110 volts; they are totally enclosed, and are rated for 25 h.p. at a speed of 300 r.p.m. They drive a worm which gears in a machine-cut gun-metal worm wheel, the power being transmitted by a machine-cut spur gear above, as shown in Fig. 1. The capstan can be used as a warping capstan, without moving the cable holder, by releasing the friction plates which couple the two together. Should it be required to work the apparatus by hand power, the shaft carrying the capstan-barrel and cable holder can be disconnected from the spur gear by a jaw-clutch of the usual type, independent safety pawls being provided for this eventuality. The capstan is fitted with a powerful screw hand-brake for lowering, and with a magnetic brake on the worm shaft. Figs. 2 and 3 illustrate a type of electrically-driven capstan designed and built by the same works for the Royal Italian Navy. The only difference between this and the machine illustrated in Fig. 1 is in the omission of the spur gear and wheel, and in the use of a larger worm gear; this latter gear can also be released by a clutch of the usual type when it is required to work the capstan by hand.

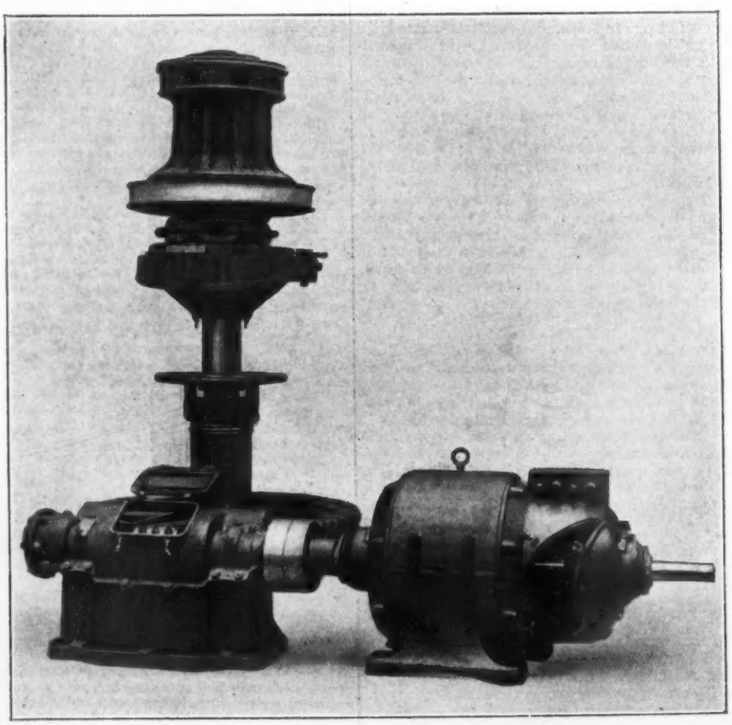


Fig. 3.

Water Power in Russia.—The important problem of a more effective and rational exploitation of Russia's wealth of water power has recently attracted much attention, and the State is contemplating active participation in this connection. Expropriation of waterfalls by the State will no doubt be resorted to on a large scale, and a move in this direction has just been made in Finland, where the State has expropriated the Little Imatra or Valinkoski Fall. The exploitation of the large Imatra Falls has been under consideration for several years, and fairly detailed plans have already been prepared with the view of transmitting at least large portions of the generated energy to the city and government of Petrograd. The exploitation of the Great Imatra Fall is closely linked together with that of the Little Imatra Fall; the two falls, in connection with the neighbouring rapids, are calculated to be able to yield annually respectively 1,400,000,000 and 1,725,000,006 k.w.h., of which 1,200,000,000 k.w.h. could be transmitted to Petrograd, which would entail an annual saving of some 3,000,000 tons of coal, equal to about 60 per cent. of the present consumption. The installation is expected to be in working order in the course of some three years, and the price for current in Petrograd is mentioned as likely to be fixed at 4 kopeks per kilowatt-hour (about 0.4*d.* per kilowatt-hour).

TELPHER INSTALLATION AT THE DALMARNOCK GAS WORKS, GLASGOW.

By G. F. ZIMMER, A.M.Inst.C.E.

IF we inquire into the history and development of gas and power undertakings we find that as soon as labour-saving or labour-aiding machinery was brought on the market these establishments were sufficiently far-sighted to avail themselves of them, and this accounts partially for the prosperity of these undertakings and for the ever-decreasing price of gas and electrical energy, the increasing value of the by-products being a good second. An important addition to the long list of labour-saving devices is the mono-rail telpher, and if we inquire further into its history we shall find again that these same undertakings have installed far and away the greatest number of telpher installations in this country, about four out of every five.

One of the most recent of such installations is that for the gas works at Dalmarnock, Glasgow; it was built and erected by Messrs. Strachan and Henshaw, Limited, of Bristol, to the requirements of Mr. Alexander Wilson, M.Inst.C.E., engineer of the Glasgow Corporation Gas Department. This plant was erected in 1914–15, and is of interest, not only as one of the latest examples, but also as being of considerable magnitude, while, lastly, it embodies some important new features.

The object of the installation may be seen from the general lay-out, Fig. 1. The coal is brought from the siding to a broken coal stock-heap on the ground, or direct into the coal hoppers in the retort house, the top of which latter is 60 ft. above the ground-level. When coal is not being brought from the siding, these hoppers are replenished by the telpher and a grab from the broken coal stock-heap. A parallel track is joined

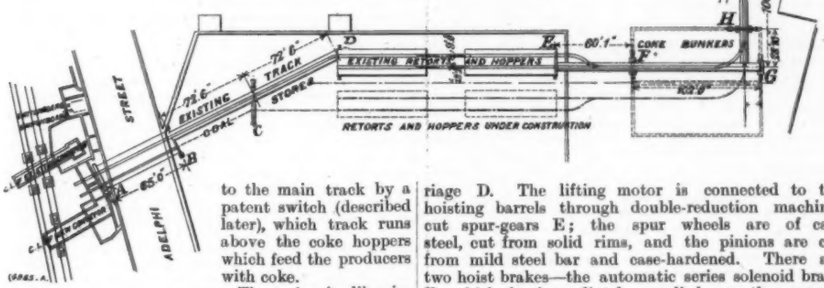


Fig. 1.

to the main track by a patent switch (described later), which track runs above the coke hoppers which feed the producers with coke.

The coke is likewise handled by the same installation as it leaves the retort-house at the right-hand side in small tip trucks, four or five of which are emptied into the telpher skip, which is lowered at this point. The coke is taken to the screening apparatus over the large ferro-concrete coke bunkers, a view of which is given in Fig. 2 on page 156, or if this should be full the coke is stored at the extreme left of the telpher run on a heap in the open (see photographic view, Fig. 3 on page 156). From here the coke is again taken by grab, similarly to the coal, and conveyed as required into the coke bunkers, from which the coke is generally drawn for sale. The sidings, which will be seen on the extreme right-hand side of the general plan, are also traversed by the telpher track, and trucks on these sidings can likewise be loaded with coke from the telpher. It will be seen that the telpher track winds its way through all the departments of the works like the main artery of the plant.

The total length of the track is about 1,100 ft., and it is supported by seven trestles, about 77 ft. from the ground, in addition to the support given to it by the retort-house; the various supports are marked with the letters A to M on the plan, Fig. 1. The dotted lines on this block plan show an addition for future extension.

The coal is emptied from the coal wagons in the usual way by two hydraulic coal tips on to a conveyor, which feeds the coal breaker. The broken coal is then elevated to the hopper over the skip-filling machine, from which point it is handled by the telpher.

Three high-speed telpher machines are at present in operation on the track, each capable of lifting and conveying 130 cub. ft. of coal or coke at each trip. The complete working cycle of filling the skip, lifting to a height of about 70 ft., conveying an average distance, and discharging, can be performed in three minutes; thus the capacity of each machine is 60 tons per hour of coal, or about 40 tons per hour of coke. Each machine is rated for lifting a gross load of 4½ tons at a speed of 90 ft. per minute, and for travelling at the rate of 600 ft. per minute; each telpher is capable of handling either a skip or an automatic grab, the latter being required to pick up material which has previously been dumped on the storage heaps of coal and coke. The method of automatically filling the skip at the coal-receiving terminus was the idea of the gas engineer, and is of special interest, as it possesses entirely new features differing from anything previously installed for the purpose, and the arrangement has proved to be very successful, the plant having been continuously at work for about a year. The details of this apparatus will be illustrated and described later.

The Telpher Track.—This consists chiefly of long spans, the longest being 102 ft. They are box-lattice girders, which are supported by box-legged trestles. Full details of typical trestles A and B are given in Figs. 4 to 19 on Plate XIII, and the longest of the girders is shown in detail in Figs. 20 to 32 on the same plate. The three short trestles F, G and H, which are carried on the concrete coal-bunkers, will be illustrated in a later issue. It will be seen from the illustrations that the telphers travel upon a renewable bulb-headed rail-track, which is clipped to the upper flange of the track-beam, suspended below the box-lattice girders.

The Telpher Machine.—Each telpher machine (see Figs. 33 and 34) has two motors, one A, 35 h.p., for lifting and one B, 8 h.p., for travelling. They are of British Thomson-Houston make, totally enclosed, series-wound, for direct current at 500 volts. The lifting motor is carried on the main frame between the two hoisting barrels C, and the travelling motor is supported on adjustable feet in the driving carriage D. The lifting motor is connected to the hoisting barrels through double-reduction machine-cut spur-gears E; the spur wheels are of cast steel, cut from solid rims, and the pinions are cut from mild steel bar and case-hardened. There are two hoist brakes—the automatic series solenoid brake F, which is immediately applied on the current being cut off from the hoist motor, and the free barrel brake G, controlled by the hand-lever H, which also actuates a safety interlocking device between the gear release and the brake. The purpose of the interlocking gear is to render any disconnection between the hoisting barrels, gear and motor impossible (these are, of course, held by the automatic brake) until the operator has taken full control of the load by means of the hand brake. As soon as the barrels are thus under control of the hand brake G, the hoist gear may be released by the handle K and bevel gear L, and the load lowered rapidly on the hand brake without doing any work on the gear or motor, thus saving a considerable amount of wear and tear.

Another important feature of these machines is the safety-hook arrangement MM. These hooks are so pivoted in connection with the hand brake that they swing outward freely by the upward pressure of the lifting bale N, with which they engage, and they are also caused to swing clear of the bale N when the hand brake is released for lowering. Thus while the machine with its load is travelling over a public street (as in this case), or over any place where the failure of the ropes, without some safeguard, would be disastrous, there is no possibility of the load becoming detached from the machine. In the event of any failure of the ropes or brakes, or their connections, the bale N is caught on the hooks MM, which are securely fixed in the frame of the machine.

The travelling wheels O are driven from the motor B by the gear wheels P and the two roller chains Q. This arrangement ensures a good grip of the motor pinion and wheels P, and naturally provides for a much longer life of the drive than the single chain drive which is commonly used. The travelling wheels are of manganese steel and keyed upon hardened Jackmanised steel axles, which are housed in Hyatt roller bearings R, of ample proportions.

The whole of the main frame, and also the driving and travelling carriages, are built up of mild steel throughout. The two-wheel carriages are freely pivoted to the main frame by means of the anti-friction swivels S and S_1, and they are connected above the track by the pivoted bar T. These two-wheel carriages are thus able to traverse sharp curves freely, without wheel-grinding and with a minimum of noise, whilst the main frame remains perfectly rigid, without being strained in any way by twisting stress. The suspension of the main frame from the swivelling carriages is also an important feature; the load is directly carried by the interlocking mild steel stirrups of substantial construction—they are only centred by the swivel pins, which do not carry any load.

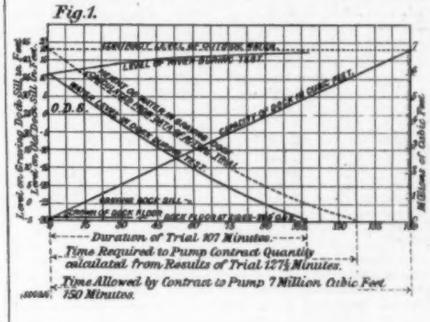
The operator's cabin is completely enclosed, and is provided with suitable doors and windows, also a seat, and the motor and brake controls are within easy reach.

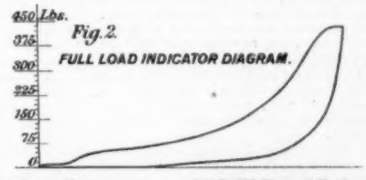
(To be continued.)

GLADSTONE GRAVING DOCK, LIVERPOOL.

Two interesting papers were read at the meeting of the Liverpool Engineering Society on the 7th inst., dealing with the Gladstone Dock, Liverpool. The chairman, appropriately enough, was Mr. Thomas M. Newell, M.Inst.C.E., the engineer-in-chief of the Mersey Dock Board, who is president of the society. The first paper was by Mr. W. Hemming Jones, M.Inst.C.E., the resident engineer on the work, who dealt with the inception, general features and mode of construction of the dock and its entrance channel; while the second dealt with the machinery, its author being Mr. W. A. Oglethorpe, M.I.Mech.E., M.I.N.A., and this dealt very completely with the pumping station. As on the occasion of the opening of the dock we fully described and illustrated the works,* and particularly the pumping

Fig. 1.


LEVEL OF WATER OUTSIDE DOCK
LEVEL OF RIVER BIDSTON 1887
LEVEL OF DOCK FLOOR
Duration of Trial 107 Minutes.
Time Required to Pump Contract Quantity calculated from Results of Trial 127½ Minutes.
Time Allowed by Contract to Pump 7 Million Cubic Feet 150 Minutes.



Scale as shown. *M.E.P. 375 Lb. per Square Inch, or 6·63 Atmospheres.* *I.H.P. 357·35 per Cylinder. I.H.P. 1429·3 per 4 Cylinders B.H.P. 1000·5 per 4 Cylinders* (9003.B)

station, some of our illustrations being reproduced in the paper, we do not propose to do more than make a commendatory reference to the two papers.

In supplement to what we published on a previous occasion, some details, however, may be reproduced from Mr. Oglethorpe's paper relating to the trials of the pumps, which are of special interest, as each of the five sets of 54-in. Worthington centrifugal pumps is driven direct by a 1,000 brake horse-power Carels-Diesel engine, of the vertical two-cycle four-cylinder type. Each cylinder has a diameter of 510 mm., the stroke of the piston being 660 mm., and the designed horse-power is attained when the engines are running at 180 r.p.m., the mean effective pressure being 6.75 atmospheres. Mr. Oglethorpe stated, regarding the trials, that the specified duty of the pumping machinery required that the graving dock be emptied in 2½ hours when pumping against a level of 18 ft. above the old dock sill, the water at the commencement to be at the same level as that outside. The capacity of the dock up to the above level is 7,000,000 cub. ft. It was not possible to obtain the above conditions at the trial, owing to the pump discharges delivering into the river, and not into the wet dock system, such as is intended when the scheme is completed. The pumping started when the levels inside and out were 11 ft. above the old dock sill, and the dock was emptied in 107 minutes, finishing against a level outside of 17 ft. above the old dock sill. After making allowance, this was found to be considerably under contract time. Fig. 1 is a diagram of the above performance. The quantity of water delivered by the pumps was 5,900,000 cub. ft., at an average speed of about 350,000 gallons per minute. The average indicated horse-power was 6,500, the average brake horse-power 4,500, and the fuel consumption per brake horse-power-hour was 0.48 lb. Fig. 2 may be taken as a specimen of the indicator cards obtained during the trial. The whole of the main pumps, together with the Diesel engine for driving them, and all the auxiliary pumps, with the electric motors for driving them, compressors, coolers, &c., were supplied by the Worthington Pump Company, Limited, London.

* See ENGINEERING, vol. xcvi, pages 4, 349, 502, 519.

THE GERMAN STEEL UNION DURING THE SECOND YEAR OF THE WAR.

The report of the German Steel Union for the financial year ended June 30, 1916, states that the second year of the war further illustrated the capability of the German industry to adapt itself to the existing contingencies. In what may be called peace commodities, railway material and sections, there was a further retrogression in manufacture, whilst in the half-finished products wanted for war material there was an increase of 18 per cent. The quantities of half-finished products dispatched during the year amounted to 64.12 per cent. of the allotment, against 54.14 per cent. for the preceding year. On the other hand, the figures for railway material receded from 68.41 per cent. for 1914–15 to 61.88 per cent. for 1915–16, and those for sections from 35.48 per cent. to 32.31 per cent.

The prices during the year under review had been materially raised owing to increase in cost of manufacture and to the position of the market, the advance during the year amounting from 15 to 17.50 marks per ton for the different goods. Export prices had also been much higher, but in the interest of the army requirements exports had been much reduced and had been subject to special control. In the former, normal times about one-third to four-fifths of the output of half-finished products and railway material were exported. The export of half-finished products during 1915–16 receded to 9.66 per cent., against 23.80 per cent. for the previous year. For railway material and sections the figures were respectively 11.28 and 15.64 per cent. and 20.81 and 21.11 per cent. The exports of the different commodities, in percentages of the total quantities for the last eight years, were :—

Year.	Half-Finished Products.	Railway Material.	Sections.
	per cent.	per cent.	per cent.
1908–9.. ..	36.27	28.25	22.47
1909–10 ..	34.00	34.47	33.45
1910–11 ..	36,92	44.08	25.64
1911–12 ..	39.69	37.19	25.61
1912–13 ..	38.14	33.97	27.93
1913–14 ..	45.87	31.64	24.93
1914–15 ..	23.80	15.64	21.11
1915–16 ..	9.66	11.28	20.81

As regards railway material the home contracts, in spite of some supplementary orders from the Prussian and the Imperial State railways, showed a decrease, as far as these railways were concerned, whilst the other German State railways, partly at least, placed higher orders than during the preceding year. A fresh three years' contract was concluded with the Prussian State railways last June (for the year 1917–1919) on the basis of 129 marks (6*l.* 9*s.*) per ton for rails. The business in rails for mining purposes had been satisfactory. As far as the foreign trade was concerned some satisfactory contracts in heavy railway materials were secured from neutral States and the Balkans, both as regards quantities and price.

As the building industry remained generally almost at a standstill, the demand for sections naturally was affected, but there was a fair demand from railway carriage manufacturers and from engineering shops. From abroad the demand was very quiet during the first half of the year, but in January it began to increase, and became active. Regard for the home market, however, coupled with the impossibility of giving prompt delivery, impeded the trade.

The business expenses during the year to be defrayed by the combine amounted to 1,835,593 marks, against 1,649,746 marks for the preceding year.

German's South American Ambitions.—The *Empire Trade Notes* for February, a monthly publication by the British Empire Producers' Organisation, contains an article under the above title stating that a circular letter, of which the following is a translation, has been posted extensively from an office in Havana :—"Recently there has been formed in Germany a vast organisation, entitled 'The German Economic Federation for Central and South America and the Antilles,' to foment export commerce when peace is declared. Its field of action will be on this side of the Atlantic, in all the Spanish-American countries. With it will be affiliated the undermentioned associations already in existence, viz. :—Argentine-Germany ; Brazil-Germany ; the Hamburg Export Union ; and the great German steamship companies. A newspaper will be published in Spanish and Portuguese to supply all information, scientific, banking and commercial, to the Spanish-American countries, and an annual publication which will give publicity to everything related to the commerce in those countries. In Berlin a club will be instituted to which we will admit all the business men and other travellers from the Americas. With peace will commence a great maritime activity. Germany is in the position of being able to place at once in active service her steamers, and will have the same tonnage at sea as before the war, even although she should not recover the steamers which are prisoners in enemy ports. The shipping constructed during the war is approximately equal to that which has been captured or destroyed. The annual subscription will be *ad libitum* from each subscriber, but not less than 120 marks annual subscription from firms, 25 marks admittance fee from firms, 30 marks annual subscription from individuals, 10 marks admittance fee from individuals. I invite you to become a member of the federation, and to that effect I permit myself to enclose a subscription form, begging you to return same with your remarks."

NOTES FROM THE UNITED STATES.

Philadelphia, January 24.

The condition of the American steel market is markedly apparent by noting that a year ago the average price of steel products was 43.90 dols. per ton and is 74.14 dols. now. The munition capacity of Canada is to be increased during the next few months to supply an additional 100,000 tons. A very strong demand has recently sprung up for 3-in. shell. Many orders for larger-size shells are being placed as rapidly as it is possible to secure acceptance. It is estimated that on January 1 the unfilled tonnage at American mills was somewhere between 20,000,000 and 25,000,000 tons. Specifications for the delivery of large quantities of this material are now coming in. A few days ago French inquiries for many steel cars were made, and since then other lesser car inquiries have been made by England, Spain and Italy. The pressure for steel cars for domestic and European use is now greater than ever in the history of car building. The expansion of capacity will help out very much. Notwithstanding the enormous pressure for supplies for structural material a large amount of business is being held up in the hope of lower prices. What reason there is for this belief is not apparent to the outside observer of trade conditions. Furnace output is being reduced by non-delivery of coke and by defective transportation facilities from furnaces. Buyers everywhere from home and abroad are ready to pounce upon the furnaces just as soon as conditions will permit. Transportation difficulties continue very serious. Railroads and Governmental authorities are driving every agency to secure prompter deliveries, and much relief from these efforts is in sight. The refrigerating industry is negotiating with foreign Governments, especially Russia, for a large quantity of refrigerating material, including refrigerating cars, and efforts were started yesterday for 10,000 such cars for quickest possible construction. Comparatively little new business in steel has been actually placed during the week, but there is pending a volume of unknown magnitude which steel-makers and equipment-makers are very anxious to accommodate.

Testing the Strength of Wet Paper.—Most kinds of paper are mechanically weak when wet. Some paper, however, *e.g.* the paper used in blue print and brown print developing, photographic paper, &c., should have sufficient strength to be handled while wet. According to Mr. E. O. Reed, of the Department of Agriculture, Washington (*Journal of Industrial and Engineering Chemistry*, November, 1916), the wet strength depends upon length of fibre, character of the beating, the kind of sizing and the formation of the sheet, but there is no direct connection between the dry and the wet strengths of a paper, so that special wet tests should be applied. He used the Schopper machine, and strips 15 mm. wide and sufficiently long to allow of immersing a length of 100 mm. in water at 70 deg. F. for 20 minutes. A rise of temperature of 5 deg. F. decreased the strength considerably, and immersion for 10 minutes only in water not at uniform temperature gave less concordant results. The wet test is also necessary for paper bags to contain cement and lime, paper textiles, &c.

German Shipbuilding During the War.—Amongst the German industries to the development of which the war has given a fresh impetus must be counted the shipbuilding industry, which also before the war worked under satisfactory conditions on the whole. Several yards, being unable to grapple with the excessive work resulting from a plethora of orders, have had to increase both capital and plant, calls to which the shareholders readily responded, thanks to the remunerative prospects in view. Among those which thus expanded may be mentioned the Howaldtswerke, at Kiel, with an increase of capital of 2,900,000 marks, the share capital now amounting to 7,000,000 marks ; the Joh. C. Tecklenborg yard, at Bremen, whose capital has been raised from 5,000,000 marks to 6,000,000 marks ; the J. Frerichs and Co. yard, at Osterholz, closely allied with the State of Oldenburg, from 2,500,000 marks to 3,000,000 marks ; and last, but not least, the comparatively small Heinrich Koch yard, in Lübeck, from 600,000 marks to 3,600,000 marks, this yard now being able, it is said, to build steamers of 12,000 to 15,000 tons. The 13 leading German shipbuilding concerns, exclusive of the Germania yard belonging to Krupp, have an aggregate share capital of 77,570,000 marks, and in spite of increased writings-off and larger sums reserved for various purposes, they were nearly all able to increase their dividend more or less, during the war. In some cases the war has wrought marked changes, as, for instance, in the case of the Frerichs yard, which closed the last year of peace with a deficit of 682,000 marks, whilst the two war years have resulted in, respectively, 179,000 marks and 184,000 marks profit. A still more striking improvement took place at the Weser yard ; against a deficit of 55,000 marks in 1914 it showed net profits amounting to no less than 926,000 marks in 1915. During the second year of the war some of the shipyards were unable to declare a dividend. The stocks in hand also show a material increase which, however, is more likely attributable to the rise in prices than to an increase in quantity. Were the latter the case the shipbuilding establishments would form an exception from the general rule of German industrial concerns at the present time, for with most of these stocks are admittedly very low. Although the present great activity at the German yards is no doubt due to work connected with the war, the industry seems hopeful as to full employment also after the war, both with home orders and orders from the outside, and no apprehension seems to exist as to competition from abroad, as the yards in the different countries are likely to be all fully employed.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Hull Coal Traffic.—For the first time the figures of the export trade *via* the Humber port are "not available" for the compilation of the monthly return. This follows upon the action of the authorities in refusing to allow the publication of statistics showing the amount of fuel exported for the purpose of the Admiralty and Allied Governments. The total tonnage dealt with at Hull during January was 263,557 tons, as compared with 274,022 tons in the corresponding period of last year, and about 43,000 tons of an increase on the aggregate for the preceding month. The Denaby and Cadeby Main collieries were the principal contributors again, but their tonnage of 22,531 tons was actually 34,000 tons of a reduction. Bentley colliery sent 3,700 tons more.

South Yorkshire Coal Trade.—The position is one of the greatest difficulty, for the problems of transport have accentuated the seriousness of the short supplies. Householders in large numbers are unable to get requirements, and during the week-end thousands of families in this area had little or no fuel at all. Manufacturers are in almost the same position, and are perturbed at the indefinite length of time taken in delivery. In certain cases orders have been given well in advance to allow for the delays, but where this precaution has been neglected firms have only about one-third of their usual reserve stocks, and are virtually carrying on a day-to-day existence. Wagon owners and users have met since these notes last appeared, but they have not arrived at any settled policy, and are meanwhile considering the tentative Government proposals. An announcement is expected at an early date. Export trade with neutrals consistently declines, but strong steps are taken to preserve the full tonnage for Allied Powers. Quotations : Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.* ; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.* ; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.* ; Derbyshire house coal, 17*s.* to 18*s.* ; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.* ; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.* ; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.* ; Derbyshire hards, 16*s.* to 17*s.* ; best slacks, 12*s.* to 13*s.* ; seconds, 10*s.* 6*d.* to 11*s.* 6*d.* ; smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at pit.

Iron and Steel.—The expansion of production proceeds with wonderful success, and accordingly there are no signs of a stoppage in the erection of new buildings, the modernisation of plant, and further dilution of labour. A steady confidence prevails that all demands will be met. Steel makers continue at high pressure, and with additional semi-skilled and unskilled labour available are getting on top of their task. All classes of semi-finished and finished goods are in big request, but the work is almost entirely of national importance. Into this category are placed agricultural implements and machinery, and whereas formerly agricultural engineers could not obtain the necessary quantities of material, they now find their improved status, consequent upon the recognition of the value of their work, enables them to get nearly all the steel they need. The material market, though unrelieved by any outstanding features, provides interest by virtue of its busy condition. Lincolnshire and Derbyshire makers find an active inquiry for both foundry No. 3 and forge qualities, and buying has been heavier than usual. The overseas supplies of pig-iron and ore are reported to be arriving irregularly, but the strong hope exists that time will bring a distinct improvement here when the full weight of the Naval operations against submarines is put into effect. No anxiety is felt, for good stocks are held here in case of whatever trouble might eventuate at sea. This applies particularly to Swedish sorts, the prices of which continue their upward career. Bar iron at 42*l.* per ton is now four times its pre-war quotation, and even 54*l.* is not asked in vain for specially fine brands. Amongst the most active branches of Sheffield trade is that of the making of wheels, axles, and general iron and steel work for rolling-stock, particularly railway wagons. Several of the large firms are concentrating upon this. Business for the non-conductive manganese tramway parts and crossings is also very good, and some municipal undertakings, unable to get orders accepted, have purchased supplies from kindred bodies who have been fortunate to hold surplus stocks. File makers record increased demands, and are erecting new shops to house additional women. Ninety per cent. of the output of a large firm of sheep-shear makers is for the Argentine, where the inability to get shearing machines has created a run upon the hand appliances. Shovel and spade makers are busy upon Government orders. The trend of the overseas trade is upward. Recent indents have been placed here for tools, files, sheep shears, saws, machine-knives, hardware, iron, steel, electro-plate, and cutlery.

Bituminous Coal Gas Producer.—An illustrated description is given in the *Iron Age* of a re-circulating type of gas producer using bituminous fuel. This is the result of experimental work begun at the University of Wisconsin and continued at Purdue University. The coal is trapped in at the top of the producer, the only air inlet being below the grates. The combustion all takes place immediately above the grates. If three things are accomplished, the gas will be free from tar :—(1) All the tar must be driven out of the fuel while it is still above the openings which communicate with the annular chamber. (2) All of the tarry vapours driven out of the fuel in the distillation zone must be drawn out and re-circulated. (3) The re-circulated gas must not be allowed to form a cold path for itself between the grates and the outlet on the one hand, nor form an explosive mixture with the entering air on the other.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Practically no appreciable change can be reported in connection with the conditions ruling in the steel industry in the West of Scotland, the same feverish activity being as rampant as ever. With every description of steel, both manufactured and semi-manufactured, now under Government control, makers find it utterly impossible to ship anything abroad except what is urgently required by the Allied Governments. In consequence, little fluctuation of price can take place meantime. The preparations for the big Spring "advance" render it more than ever necessary that the output of munitions and the various other requirements should be speeded-up with all possible haste, so that steel manufacturers who have construction and reconstruction in progress are having these rapidly pushed forward in order to meet the ever-increasing demand. Plates, sections and bar steel for shells continue to be of the utmost importance, and are being produced in enormous quantities. Prices for ship and boiler plates, and for angles, are unaltered over the week.

Malleable Iron Trade.—The malleable iron trade would almost seem to have reached the high-water mark of activity, for with so many of the mills having been turned on to the rolling of steel, no greater output of bar-iron could possibly be attempted. All things considered, an extraordinary tonnage is being put through; but, so long as the demands of our own and the Allied Governments remain at the present level, ordinary mercantile business—home and foreign alike—stands but a poor chance of any consideration whatsoever. This curtailment is seriously handicapping the operations of certain consumers, but unquestionably the material required for war purposes is of first importance, and all else must stand aside. "Crown" bars continue to be quoted about 14*l.* 12*s.* 6*d.* or 14*l.* 15*s.* per ton.

Scotch Pig-Iron Trade.—So great is the demand for pig-iron of every grade that every furnace is kept running at the fullest possible pressure, and even with this makers are not yet sure that they will be able to execute all the orders which continue to pour in. The local steel works readily absorb the entire output of hematite, vast as it is, and very little forge quality remains after the wants of the malleable iron makers have been satisfied. Every endeavour continues to be made to increase the output, not an easy process under existing circumstances. Very little export business is being put through. Except where not fixed, prices are steady and unchanged during the past week.

War Loan.—During the week quite a number of important firms in the iron, steel and allied industries in the West of Scotland have made offers to their workers similar to those mentioned here a week ago, among those being Messrs. John Brown and Co., Clydebank; Messrs. David Colville and Sons, Motherwell; the Coltness Iron Company, Limited, Newmains; the Chapel Coal Company, Limited, Newmains; the Glasgow Steel Roofing Company, Limited, and others. In every instance the matter has been enthusiastically taken up, the workers thus demonstrating their willingness to aid the State by lending their prospective savings during the next year. The patriotism of the firms concerned deserves high commendation, for all have already been generous subscribers to the War Loan.

Shipping Freights and Profits.—At the annual meeting of the Clyde Steamship Owners' Association, held in Glasgow on Monday, it was intimated by the president, Mr. T. Paterson Purdie, in moving the adoption of the report, that particularly good profits had been earned by the few mercantile marine owners who had been in a position to "carry on." Out of these profits 60 per cent. of all excess over pre-war rates, plus 5*s.* per £ of ordinary taxation, had found its way into the National Exchequer in the form of war taxes, thus showing that the greater the profit the greater the benefit to the State through the channel of the mercantile shipping trade. The ultimate result to the British shipping trade itself however, is not too advantageous, owing to the profits which have accrued to the owners of vessels belonging to neutral countries, as the large increase in revenue has encouraged much new building and a considerable expansion of the already existing mercantile fleets. These facts show more than ever the necessity there is for the activities of the Ship Controller being pursued with the utmost possible enthusiasm.

SPONTANEOUS GENERATION OF HEAT IN RECENTLY HARDENED STEEL.—At the meeting of the Royal Society, held on Thursday, the 8th inst., a paper on this subject was submitted by Mr. C. F. Brush and Sir Robert Hadfield, F.R.S. This paper stated that steel specimens of different composition were hardened and then placed in Dewar vacuum jars so arranged as to have equal thermal insulating efficiency. These were placed inside an airtight cylinder of thin copper embedded in granulated coke placed in another box surrounded by an air space and a further box. The special apparatus employed is fully described in the paper. Carbon steel, also nickel-chromium steel specially susceptible to hardening, and other steels were then quenched from hardening temperatures, and when cold placed in the vacuum jars and the temperatures carefully recorded in the manner described in the paper. It was found that there was an evolution of heat of minute but appreciable quantity. As regards the bearing of this research as applied to industrial practice, whilst the rise of temperature is minute and may not have any direct bearing upon hardening results, the curious phenomenon noticed throws light upon the serious stresses and strained condition of the material produced in large masses of steel during hardening operations.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is a moderate amount of business passing in Cleveland pig-iron. Home consumers are very well placed, and are not compelled to buy for early requirements, but some of them are negotiating for supplies over the second quarter of the year, and forward arrangements are favoured by makers, as there seems little likelihood of any difficulty as regards allocations, and such sales obviate making numerous small contracts. With maximum quotations in force, all forward contracts are subject to any official alteration in prices. At present change in quotations is not anticipated. Regular deliveries to home users are still handicapped by shortage of trucks. Business with our Allies is fairly large, and there are occasional inquiries on behalf of customers in neutral countries. For home consumption No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge all stand at 87*s.* 6*d.*, and No. 1 is 91*s.* 6*d.* For shipment to our Allies No. 3 is 97*s.* 6*d.*; No. 4 foundry, 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*; and No. 1, 102*s.* 6*d.*; and for export to neutrals the minimum rates named are 105*s.* for No. 3, and 110*s.* for No. 1.

Hematite Iron.—Little difficulty is experienced in fully satisfying all home requirements for hematite iron, the only interruption to supply being the lack of transport facilities, and very considerable quantities are now on sale for export, with the result that, as licence for shipment is nothing like so difficult to secure as it has been, arrangements are being made for the dispatch of substantial parcels to our Allies. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Coke.—Local demand for coke continues on a good scale, and fixed maximum quotations still rule, 28*s.* at the ovens being the price of average blast-furnace kinds, and 30*s.* 6*d.* at the ovens the quotation for qualities low in phosphorus.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel are kept very busily employed, and the now enormous output is still growing by the steady extension of works. A new local steel company has been formed, with a capital of 100,000*l.* It is gratifying to be assured that notwithstanding the continued pressure for delivery of other descriptions, the heavy production of mercantile shipbuilding material is increasing. Values are fully maintained. The following are among the principal market quotations to home customers:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l* 2*s.* 6*d.*; double best bars, 14*l*, 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 12*l.*; packing iron and steel (tapered), 14*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates 11*l*, 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 19*l.* to 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel joists, and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

Trade Statistics.—The Middlesbrough Chamber of Commerce returns just issued show that at the end of December last, of 77 blast-furnaces erected within the port of Middlesbrough, 50 were blowing, as compared with 43 in operation twelve months earlier. The output of pig-iron within the port of Middlesbrough during the last quarter of 1916 is estimated at 625,000 tons—268,000 tons Cleveland pig-iron and 357,000 tons hematite, spiegel, basic, and other special irons. For the previous three months the production was 579,000 tons—236,000 tons Cleveland pig-iron and 343,000 tons hematite, &c.—and for the last quarter of 1915 the production amounted to 533,000 tons—247,000 tons Cleveland pig-iron and 286,000 tons hematite, etc. Imports of iron ore to Middlesbrough last quarter reached 389,754 tons, as compared with 668,698 tons for the previous three months, and 489,437 tons for the last quarter of 1915. The total value of goods other than coal and coke exported to foreign and colonial destinations from Middlesbrough last quarter reached 3,004,679*l.*, as compared with 2,884,412*l.* for the corresponding period of 1915—an increase of 120,267*l.*

SULPHATE OF AMMONIA.—The Food Controller, with the concurrence of the Agricultural Departments of Great Britain and Ireland, has approved of an arrangement whereby, on or after Monday, the 12th inst., sulphate of ammonia is to be sold at the price of 16*l.* per ton, 24½ per cent. basis, in maker's bags, net cash, delivered at the consumer's station in any part of the United Kingdom. The price to consumers who take delivery at the producer's works for conveyance otherwise than by railway remains at 15*l.* 10*s.* per ton. In the event of purchasers experiencing difficulty in obtaining supplies locally, they should apply to the Secretary, Sulphate of Ammonia Advisory Committee, 84, Horseferry-road, London, S.W. The Food Controller has appointed, with the concurrence of the Agricultural Departments of Great Britain and Ireland, the following Committee of Manufacturers of Sulphate of Ammonia to advise him with regard to questions affecting its production and distribution, and to give effect to an approved scheme for regulating the distribution of supplies to farmers in all parts of the United Kingdom:—Mr. D. Milne Watson (chairman), Gas Light and Coke Company; Mr. Wm. Fraser, Pumpherston Oil Company, Limited; Mr. E. J. George, Consett Iron Company, Limited; Mr. W. R. Hann, Powell Duffryn Steam Coal Company, Limited; Mr. N. N. Holden, Messrs. Hardman and Holden, Limited; Mr. A. K. McCosh, Messrs. Wm. Baird and Co., Limited; Alderman F. S. Phillips, Salford Corporation Gas Department; Mr. A. Stanley, Messrs. Simon-Carves, Limited; Mr. F. C. O. Speyer (Secretary).

NOTES FROM THE SOUTH-WEST.

The Coal Market.—Idle and dull conditions have prevailed on the coal market again during the past week. The further substantial increase in freight rates for neutral vessels has not yet had time to bring along tonnage. Meanwhile shipping has remained very scarce, while the position in the coalfield is very uncertain from more than one point of view. In the first place, there have been many intermittent stoppages consequent upon the shortage of wagons, arising primarily from the lack of tonnage. The Board of Trade have suggested that, with a view of overcoming the difficulty, small coal should be placed on the banks instead of in coal trucks. It is too soon, however, to know what effect this arrangement will have, and for the moment no improvement is noticeable. This remark applies more particularly to the anthracite area of the coalfield where, in many cases, work is only carried on for three days a week. Another incident worthy of note is the rejection on the part of the South Wales miners at a delegate conference to agree to the arrangement made between the Committee of the National Federation and the Home Secretary in regard to "combing out." Consequent upon this decision the conference had to be adjourned until next Monday, and the result of this adjourned meeting is awaited with keen interest, as it is quite uncertain as to what line of policy the Welsh miners, through their delegates, will now adopt. The South Wales coalowners have now definitely launched their scheme for the purchase, supply and distribution of home-grown timber for use at the pits. This new departure is of particular interest and importance at the present juncture, as it is hoped that it will result in a considerable saving of tonnage which is now employed in bringing supplies of timber from abroad. In the meantime prices are nominal and dependent on the individual position of operators. Buyers with ready tonnage can secure supplies of all classes of coal on practically their own terms. Best Admiralty large is monopolised by the authorities, but second Admiraltes are round 25*s.*, Black Veins and Western Valleys 24*s.* 6*d.*, and Eastern Valleys from 22*s.* to 23*s.* 6*d.* The export demand for bituminous sorts is also infinitesimal, and No. 3 Rhondda large are round 25*s.*, No. 2 Rhondda large, 23*s.*, No. 2 throughs, 19*s.*, and smalls from 15*s.* Small steams are in abundant supply, and it is stated that some hundreds of wagons of smalls are standing in the dock sidings. Best bunker descriptions command at top 16*s.*, good cargo smalls 14*s.* 6*d.*, and inferiors from 8*s.* 6*d.* Swansea Valley big-vein large is round 23*s.*; Paris, French and stove nuts, 34*s.*; best large steam, 26*s.*; and bunker smalls, 15*s.* 6*d.* Coke and patent fuel have also been adversely affected by the tonnage shortage. Ordinary foundry coke for export is obtainable at 55*s.* and patent fuel down to the limitation price of 30*s.* Pitwood remains as scarce as ever, and the record price of 70*s.* has been paid on more than one occasion, and some sellers indicate up to 75*s.*

Finance.—Emlyn Line, Limited, final dividend 12½ per cent., making 25 per cent. for the year, free of tax.—Fernhill Collieries, Limited: Interim dividend on preference shares for half-year ended December 31 at the rate of 7 per cent. per annum, less income-tax.—Trade of Bute Docks in 1916, 11,084,296 tons, against 11,433,506 tons in 1915 and 13,676,941 tons in 1913.—Port Talbot Graving Dock and Shipbuilding Company, Limited: Interim dividend of 5 per cent. on ordinary share capital, free of tax.—Globe Shipping Company, Limited: Final dividend of 17½ per cent., less tax, making 25 per cent. for year 1916.—Powell Duffryn Steam Coal Company, Limited: Dividend of 11 per cent. actual, free of tax, on ordinary shares for half-year ended December 31, making 20 per cent. for year. Dividend at rate of 6 per cent. on preference shares for half-year.—Consolidated Cambrian, Limited: Recommend dividend on preference shares at rate of 6 per cent. per annum, for six months ended December 31, and at rate of 15 per cent. per annum on ordinary shares, making dividend of 10 per cent. for year and bonus of 5 per cent.—D. Davis and Sons, Limited: Final dividend for half-year ended December 31 at rate of 20 per cent. per annum, less tax. This, with interim dividend of 20 per cent. and bonus of 10 per cent., makes, for the year, a dividend of 30 per cent. and a bonus of 10 per cent.

THE INGLIS PATENT FOR STEAM BOILERS.—In the Scottish Court of Session last Tuesday Lord Dewar directed that the life of the Letters Patent No. 5939, of 1903, granted to Mr. Inglis "for improvements in and relating to fire-tube steam boilers in the marine or like type," and assigned by him to the Inglis Boiler Syndicate (Limited), 83, Renfield-street, Glasgow, be prolonged by seven years.

SHIPBUILDING IN SWEDEN, RUSSIA AND NORWAY.—There seems no end to the new schemes about shipbuilding establishments to be started in the different countries. Thus, a new yard has been put down on the Swedish west coast, at Halmstad; it is to have a minimum of five slips, and a dry dock, whilst it is proposed to start with a staff of some 600 hands; the plan provides for raising the number to 5,000. In Russia, new shipbuilding projects are under contemplation, owing to the inability of the existing yards at Petrograd and on the Black Sea to do much work apart from that required for the Russian Navy. The erection of shipyards is contemplated at Kertsch and on the coast of the Arctic Ocean. The Rosenborg yard at Stavanger, Norway, has now undertaken to build vessels of 9,000 tons, the largest vessels, if we mistake not, so far built in Norway. The Finspong works in Sweden are to build the engines.

TELPHER INSTALLATION AT THE DALMARNOCK GAS WORKS, GLASGOW.

MR. ALEXANDER WILSON, M. INST. C.E., ENGINEER; MESSRS. STRACHAN AND HENSHAW, LIMITED, BRISTOL, CONTRACTORS.

(*For Description, see Page* 153.)

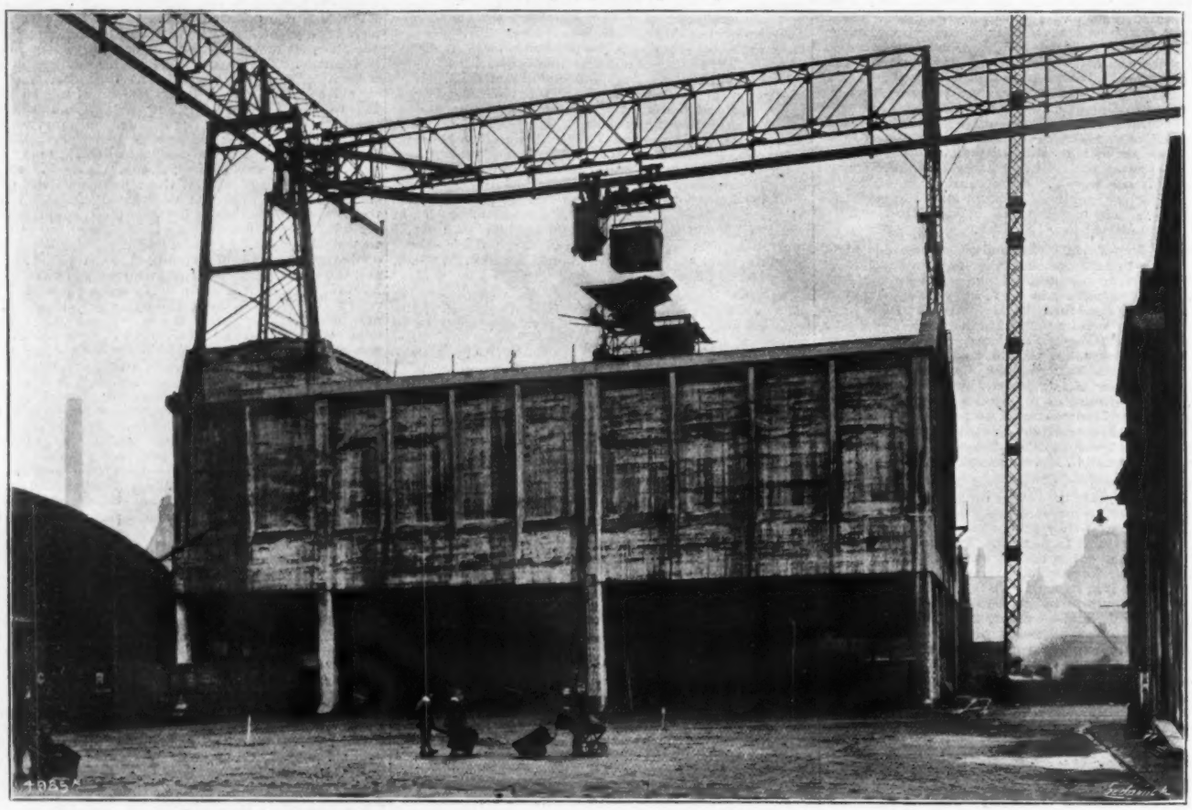


Fig. 2. Ferro-Concrete Coke Bunkers with Telpher Track and Trestles F, G, H.

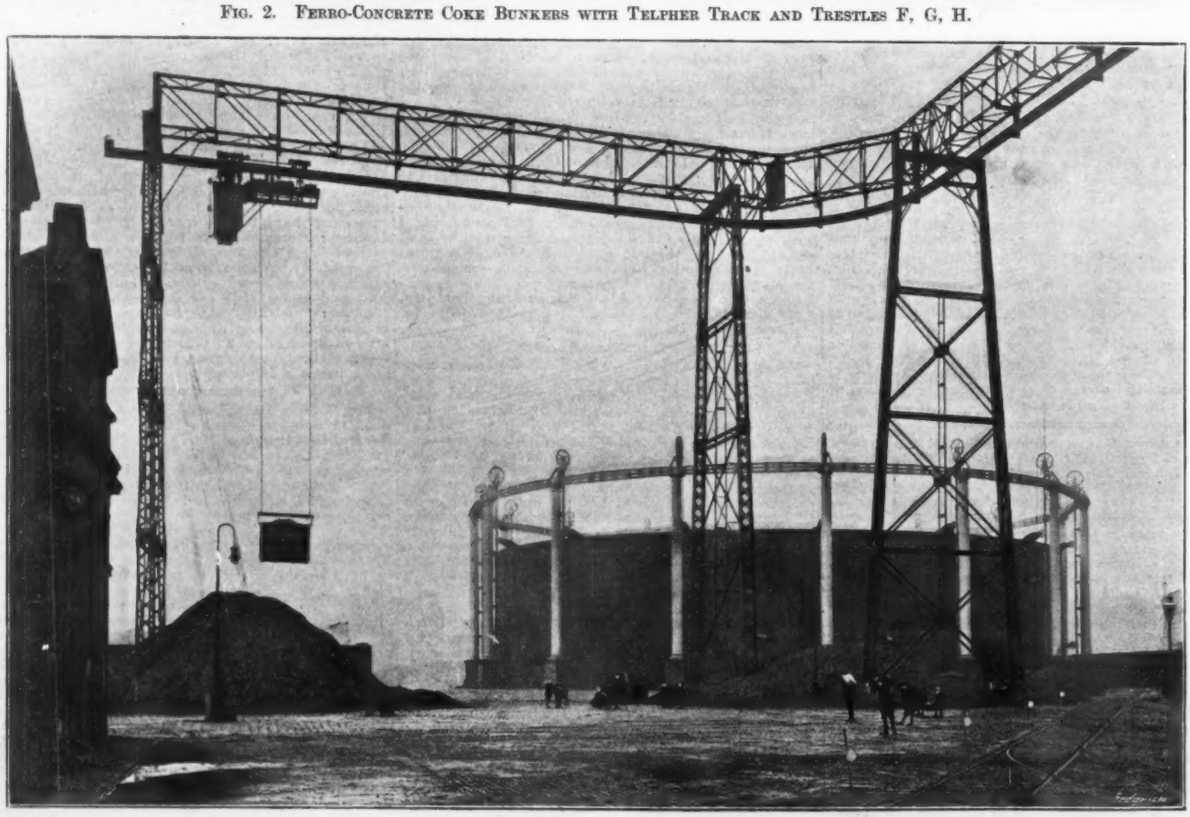
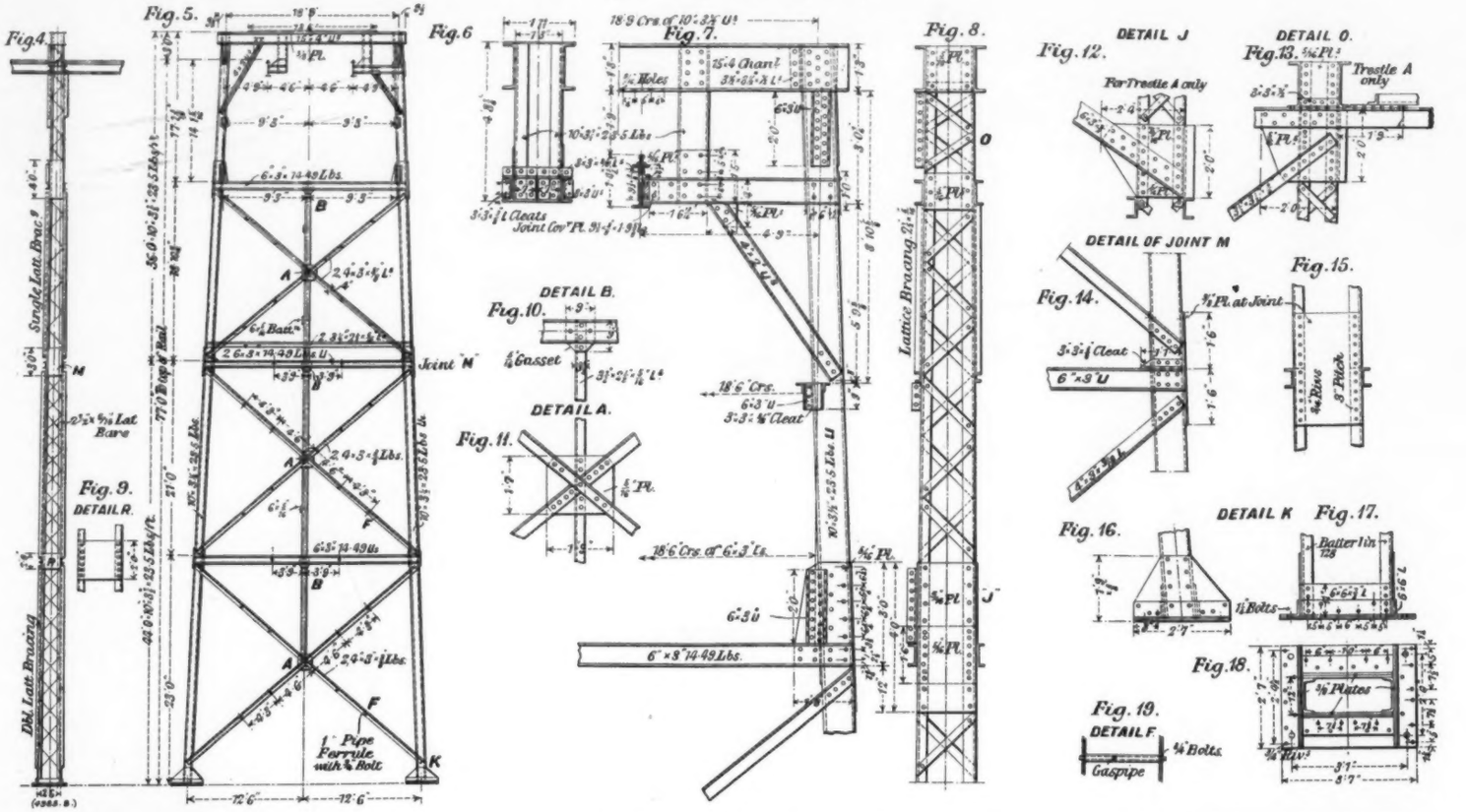


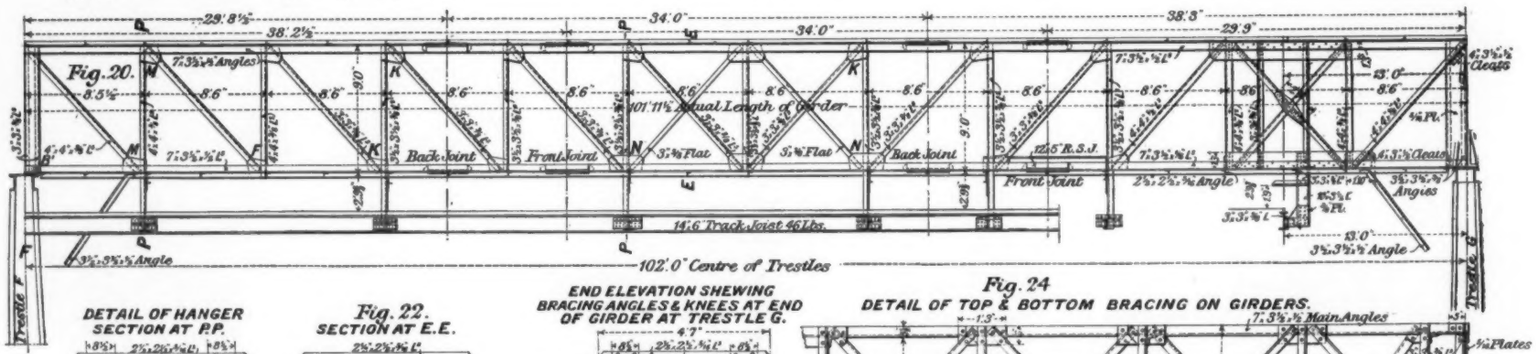
Fig. 3. Coke Store Heap in the Open.

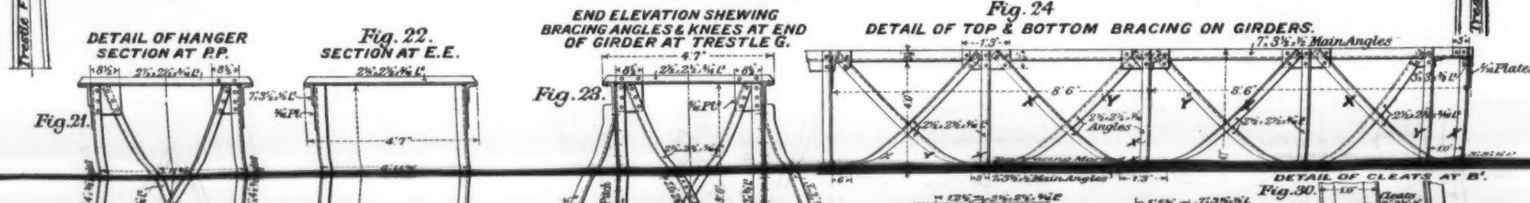
TELPHER INSTALLATION AT THE DALMARNOCK GAS WORKS, GLASGOW.

MR. ALEXANDER WILSON, M. INST. C.E., ENGINEER TO THE GLASGOW CORPORATION GAS DEPARTMENT; MESSRS. STRACHAN AND HENSHAW, LIMITED, BRISTOL, CONTRACTORS.

(For Description, see Page 153.)






DETAIL OF HANGER SECTION AT P.P.
Fig. 21.
Fig. 22.
SECTION AT E.E.
END ELEVATION SHEWING BRACING ANGLES & KNEES AT END OF GIRDER AT TRESTLE G.
Fig. 23.
Fig. 24
DETAIL OF TOP & BOTTOM BRACING ON GIRDERS.
DETAIL OF CLEATS AT B'.
Fig. 30.

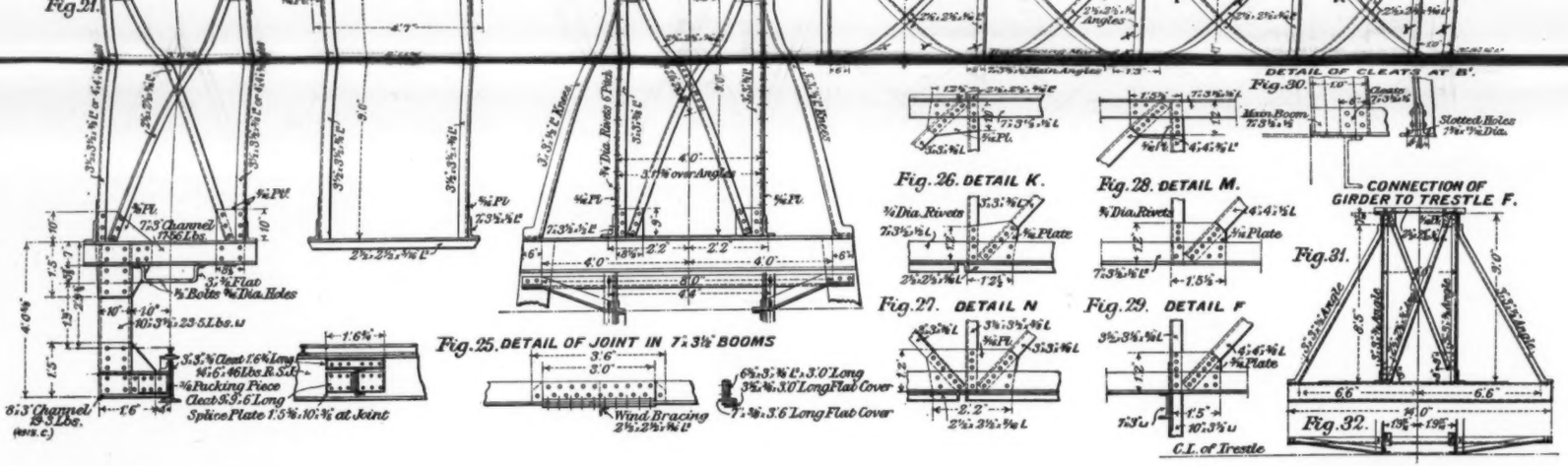


Fig. 25. DETAIL OF JOINT IN 7"x3½" BOOMS
Fig. 26. DETAIL K.
Fig. 27. DETAIL N
Fig. 28. DETAIL M.
Fig. 29. DETAIL F
Fig. 30.
DETAIL OF CLEATS AT B'.
CONNECTION OF GIRDER TO TRESTLE F.
Fig. 31.
Fig. 32.
C.L. of Trestle

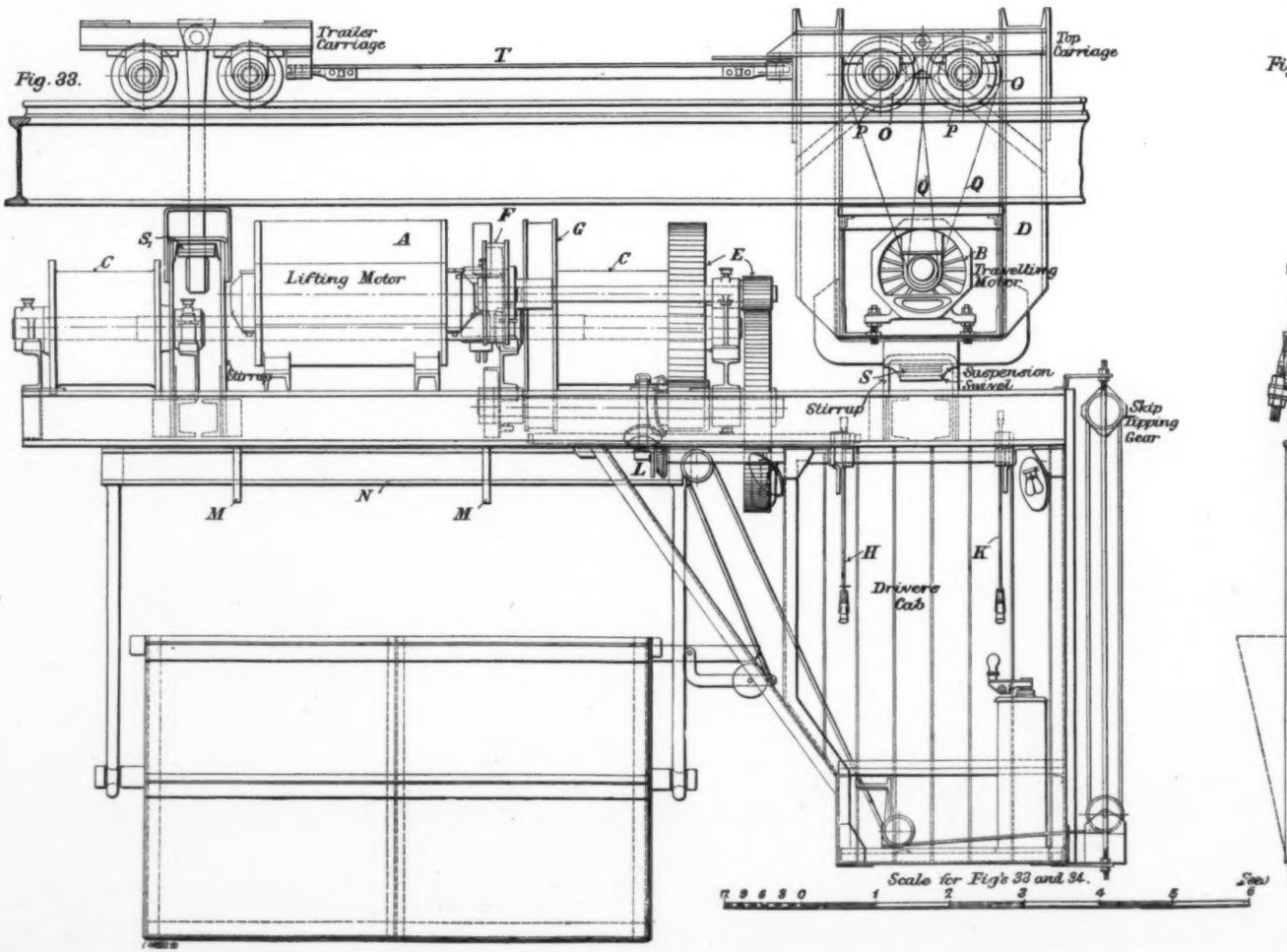


Fig. 33.
Trailer Carriage
Top Carriage
Lifting Motor
Travelling Motor
Suspension Swivel
Skip Tipping Gear
Driver's Cab
Scale for Fig's 33 and 34.

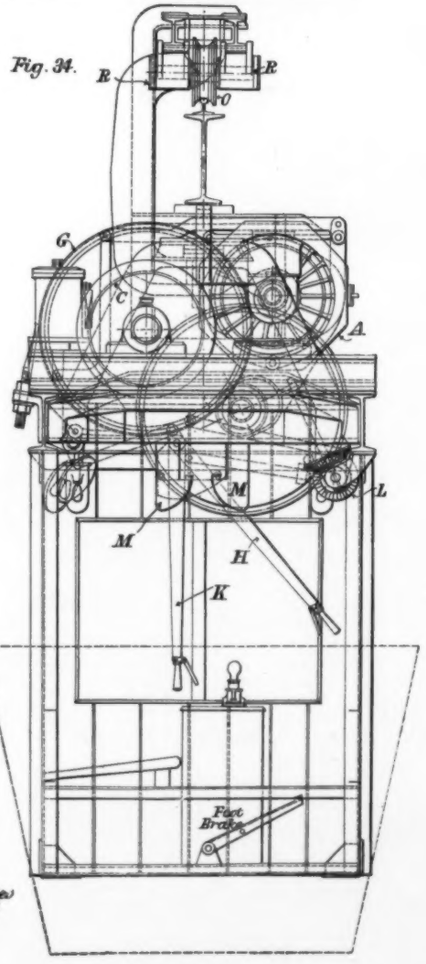


Fig. 34.
Foot Brake

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CONTENTS.

	PAGE
The Arrangement of Machine Shops.—No. X (*Illus.*)	145
Portable Trench Pump Set (*Illus.*)	149
The "Peters" High-Purchase Grab (*Illus.*)	149
Industrial Notes	150
The Physical Society of London	151
Electrically-Driven Capstans for the Brazilian Navy (*Illus.*)	152
Telpher Installation at the Dalmarnock Gas Works, Glasgow (*Illus.*)	153
Gladstone Graving Dock, Liverpool (*Illus.*)	153
The German Steel Union during the Second Year of the War	154
Notes from the United States	154
Notes from South Yorkshire	154
Notes from the North	155
Notes from Cleveland and the Northern Counties	155
Notes from the South-West	155
Mechanical Difficulties in the Evolution of the Steam Turbine	157
Honours to War Workers	158
Suggested Modification of the Whitworth Screw Thread (*Illus.*)	158
Notes	159
Literature	161
Books Received	161
The Longitudinal Strength of Guns (*Illus.*)	162
Worm Gear and Worm Gear Mounting	163
The Standardisation of the Marine Engine	163
"Skill and Payment"	163
Electron, Quanta and Relativity Theories	163
Screw Gauges	163
Aluminium Resources of the Central Powers	164
The late Frederic William Marchant	164
The Optical Society	164
Screw Thread Measurement (*Illus.*)	165
American Naval Stations and Naval Bases	166
Colonial and Foreign Engineering Projects	167
ENGINEERING Patent Record (*Illus.*)	168

With a Two-Page Plate of the TELPHER INSTALLATION AT THE DALMARNOCK GAS WORKS, GLASGOW

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, February 16, at 6 p.m. Annual general meeting at the Institution of Civil Engineers, Great George Street, Westminster. The annual report of the Council will be presented. A paper on "Alternating Stress Experiments," by Mr. William Mason, D.Sc., Associate Member, of Liverpool, will also be read and discussed.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Friday, February 16, at 7.30 p.m., at the Rooms, 207, Bath Street, Glasgow. Dr. Alex. Russell, Vice-President, will deliver his Kelvin Lecture, entitled "Some Aspects of Lord Kelvin's Life and Work."

THE ASSOCIATION OF MINING ELECTRICAL ENGINEERS: MIDLAND BRANCH.—Saturday, February 17, at 3.30 p.m., at the Midland Hotel, Mansfield. Paper for discussion:—"The Steam Turbine and its Industrial Application," by Mr. P. J. Plevin, A.M.I.E.E.

THE ROYAL SOCIETY OF ARTS.—Monday, February 19, at 4.30 p.m. Cantor lecture.—"The History and Practice of Town Planning and Civic Architecture," by Professor A. Beresford Pite, F.R.I.B.A., Royal College of Art, South Kensington (Lecture IV). Wednesday, February 21, at 4.30 p.m. "The Training of Educated Women for Secretarial and Commercial Work, and their Permanent Employment," by Mrs. C. Hoster, Hon. Secretary of the Society for Promoting the Employment of Women, and Vice-President of the Society of Women Journalists. The Lady Emmott will preside.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, February 20, at 5 p.m., at the Royal Society of Arts, John Street, Adelphi, W.C. A paper on "The Effect on the Eye of Varying Degrees of Brightness and Contrast" will be read by Dr. James Kerr, Public Health Department, London County Council.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 20, at 5.30 p.m. Paper to be further discussed:—"The Main Drainage System of London," by Mr. George William Humphreys, M.Inst.C.E. Paper to be submitted for discussion:—"The Commercial Metering of Air, Gas and Steam," by Mr. John Lawrence Hodgson, B.Sc., Assoc.M.Inst.C.E.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, February 20, at 8 p.m., at the Royal Society of Arts, John Street, Adelphi, W.C. The following paper will be read:—"Liquid Fuel and its Combustion," by Professor J. S. S. Brame.

THE INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, February 21, at 7 p.m., at the University, Edmund Street. Discussion on "Fuel Economy," to be opened by short papers by Mr. J. Frith and Mr. D. Paton.

THE AERONAUTICAL SOCIETY OF GREAT BRITAIN.—Wednesday, February 21, at 8 p.m., at the Royal Society of Arts, John Street, Adelphi, London, W.C. Lecture (followed by discussion) on "The Less Satisfactory Materials of Aircraft Construction," by Captain G. S. Walpole, D.Sc., A.I.D.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, February 21, at 5 p.m., at 70, Victoria Street, Westminster. Papers to be read:—(1) "The Heat Balance of the Atmosphere," by Mr. W. H. Dines, F.R.S., F.R.Met.Soc. (2) "Continentality and Temperature," by Mr. C. E. P. Brooks, M.Sc., F.R.Met.Soc. Sir Napier Shaw will exhibit some photographic transparencies of cloud forms.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 23, at 5.30 p.m. The evening discourse will be delivered by Mr. H. Wickham Steed. The subject is "Some Guarantees of Liberty." Afternoon lectures next week at 3 p.m. Tuesday, February 20. Professor Charles S. Sherrington, M.D., LL.D., D.Sc., F.R.S., Fullerian Professor of Physiology, R.I., on "Pain and its Nervous Basis" (Lecture VI). Thursday, February 22. Professor Edward S. Prior, A.R.A., M.A., F.S.A., Slade Professor of Fine Art, Cambridge, on "Memorial Art in History" (Lecture I). Saturday, February 24. Mr. Daniel Jones, M.A., Reader in Phonetics in the University of London, on "The Pronunciation of Languages in General" (Lecture I).

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, FEBRUARY 16, 1917.

MECHANICAL DIFFICULTIES IN THE EVOLUTION OF THE STEAM TURBINE.

STAGGERED by the mechanical troubles which arose in connection with the development of one of the early designs of dynamos, an American investor is recorded as declaring that he wished he had decided to support a rival type, not realising that the annoying and expensive incidents were the badge of all the tribe and were merely the inevitable accompaniment of pioneering work of this character. A few years ago agents for steam turbine builders quite frequently attempted to push their own wares by proffering long lists of the mishaps which had overtaken other makes, and from which they asserted their own particular type was immune. The only ground for this assertion, when, if ever, it happened to be true, lay generally only in the novelty of their own wares. "Happy is the country that has no history," and if only a few turbines of a particular type had been built the opportunities for creating a history of misadventures was inevitably lacking. This kind of salesmanship suffered from the drawback that when the new pattern, in its turn, met with misadventures, retaliation was inevitable, and as a consequence many engineers were led to consider the danger of breakdown of any type of steam turbine so serious as to make their adoption impossible, and many large reciprocating sets were installed during these years where the conditions were really such as to make the turbine a much more desirable machine.

In the early days, for example, it was asserted that blade stripping was confined to reaction turbines, with their necessarily small clearances over blade tips. Agents for impulse machines drew attention to the large clearances over blade tips which could be adopted with this type, and claimed, accordingly, complete immunity from this particular evil. Experience, however, soon proved that this proposition was *ben trovato* rather than *vero*, as strips with the earlier impulse turbines were so serious that at the Skodawerke, for example, almost the whole of the profits of the turbine department during the earlier years were swallowed up in replacing blades in turbines which had stripped before being taken over by their purchasers. Much expensive experience had to be paid for before both the design and the material of the blades became satisfactory. This circumstance shows clearly that stripping may result from other causes than small clearances. In fact, in the so-called disc and drum machines it has often been found that the blades of the velocity compounded wheel have been the first to go. This has been the case, at any rate, in power-station practice, where the temperature and the speed of the steam are both high. The matter, no doubt, is mainly a question of design and of materials. The suitability of either is hardly capable of determination by laboratory experiments. It is now ancient history that 25 per cent. nickel steel proved a failure wherever used, and the A.E.G. have had disastrous experiences with 32 per cent. nickel steel even when used for stationary guide-blades. The soft brass alloy which has been so successfully used for Parsons' blading has been known to cut away inside of a fortnight when adopted for a velocity-compounded wheel.

A prolific source of blade breakages has been the chance synchronisation of the natural periodicity of the blade, considered as a vibrating elastic solid, with some periodic impulse either inside or outside the turbine. This was, we believe, first observed with the exhaust blading of the first large steam turbine built by Messrs. Brown, Boveri and Company. In reaction turbines the fixed blades are commonly replaced by solid stoppers, at the joint of the turbine casing. There is thus an interruption, partial or complete, in the supply of steam to a moving blade whenever it passes the joint, and should the periodical time of passing these points agree with the natural period of vibration of the blade, breakage is inevitable. The remedy, which was successfully applied by Messrs. Brown, Boveri and Co. to the case mentioned, was to alter the rate of vibration by soldering an additional lacing wire to the blades at mid height. In the case of impulse turbines the use of partial admission stages also introduces a certain periodicity into the forces acting on the blades, and many breakages have been caused in this way. The remedy is, as before, a simple one, viz., to get rid of this synchronism between the varying force and the vibrator by stiffening the latter. Occasionally, however, this leads to curious results. Certain cases of failure having occurred from causes of this kind, the blades were stiffened by thickening the roots. This proved highly satisfactory until the stiffened blades were used upon a new size and pattern of turbine. With the introduction of this, breakages again appeared, but the blades broke not at the root, but at a point nearly one inch higher up.

The earlier turbines worked with saturated or but slightly superheated steam, and the introduction of higher superheats occasioned a plentiful crop of troubles. In the case of reaction turbines these commonly took the form of drums getting loose on their end shafts, due to the unequal expansion by heat of the body of the drum and of the stub connection on to which it was shrunk. This difficulty has long disappeared, owing to suitable modifications in the design. With both impulse and reaction turbines troubles arose through the distortion of the casing, owing generally to some lack of symmetry in the design or inequality in the

rate at which heat is convected away from opposite sides. A hot casing will, in fact, hog considerably if uncovered. The air currents set up cool the under side more than the top, since they are already hot when they get there. Unequal expansion of this kind was a prolific source of trouble in the early days of the impulse turbines. At the best it meant a bent or broken shaft; whilst in other cases the trouble was still more serious, as in the case of the cruiser Mainz, to which turbines were fitted by the A.E.G. In this case the shaft welded itself solid to the diaphragms, through which, of course, the clearance had to be very small.

The difficulty arising from small shaft clearances was overcome by adopting Mr. Gerald Stoney's maxim that when one surface is to run at a high speed near another surface and with but a small clearance between, one of the two surfaces must be a mere thin edge. Once stated, the commonsense of this principle appeals to all, and it has been universally adopted by turbine builders the world over. Its discovery was, however, by no means either obvious or easy. Its general adoption has abolished any serious trouble from small clearances, but minor ones still occasionally appear. Two instances are known in which dummy grooves have been washed away by the leakage steam, leaving the metal everywhere fully $\frac{1}{8}$ in. clear of the opposing dummy strips, for which nickel had been used. No explanation of this extraordinary occurrence has so far been found. Again, although the adoption of Stoney's principle has stopped the breakage of shafts by distortion troubles, the latter are probably responsible for the vibrations still occasionally experienced with two 7,000 kw. A.E.G. turbines. As originally delivered this trouble was so serious that the turbines were unable to take more than one-third of their rated loads, and had to be entirely rebuilt. This enabled them to take their loads if carefully operated.

With the increase in the sizes and speeds of turbine wheels another vibration trouble made its appearance. In certain cases, fortunately somewhat rare, the wheel itself begins to vibrate under the influence of certain forces which synchronise with its own periodicity. The periphery takes the form of a standing wave, which remains stationary in space whilst the wheel itself rotates. The wave consists of a displacement of the rim axially from its normal position when at rest. There are usually four wave-lengths comprised in the complete circumference of the wheel. At four points the crests of the standing wave touch one of the two diaphragms between which the wheel is running, and at four intermediate points the troughs or "negative" crests of the wave touch the other diaphragm. Four points of wear are thus found on each. The result, unless the turbine is at once shut down, is that the rim gets red hot, wears away, and lets the blades out, causing a more or less complete strip. The clearance between the two diaphragms is commonly made as small as practicable, so as to shorten the overall length of the turbine, thus increasing the stiffness of the rotor. For the same reason the wheels are generally made thin, with a consequent reduction in their stiffness.

At one station two machines, both recent productions of the A.E.G., developed this trouble. On opening up one of the turbines it was noted that the offending wheel continued to vibrate in unison with some part of some other machine in the station, so that it appears possible that the trouble may have been started by something quite external to the turbine itself. In any case, the phenomenon is highly erratic. Two machines, both rated at 20,000 kw., were built from the same drawings. The first to be delivered has run without the slightest trouble ever since its erection. The other, whilst under test in the builder's shops, developed in one of its wheels the standing wave as above described, and had to be, to some extent, reconstructed. Possibly the difference in the behaviour of the two machines may be due to slight differences in the rigidity of the joint between the wheel and the shaft. Two forced fits can never be exactly the same, and in the case of the A.E.G. machines already referred to it was found that the vibration was completely cured by clamping to the wheel a weight of a few ounces.

HONOURS TO WAR WORKERS.

Consistent with the spirit of strenuousness and stern activity which characterises the Empire to-day, it is gratifying to find that work for the Empire is most obviously the reason for the conferments of honour by His Majesty the King, recorded in the list issued this week, its publication having been deferred from New Year's Day owing to the change in the premiership. In practically no case is political influence evident, but reasons, based on meritorious work, are enunciated justifying every distinction conferred upon the recommendation of the Prime Minister and his associates. It thus follows almost inevitably that engineers figure more numerously in this list than on preceding occasions. All recipients of honours have done war work, but it may be accepted that with only one or two exceptions this work has been done in connection with the administration of Government Departments, rather than in actual manufacture of engineering appliances for the prosecution of the war. We await with confidence the rightful distribution of rewards which have been won in connection with actual munition manufacture, while expressing in the highest degree satisfaction at the distinctions now conferred upon engineers who have temporarily left the factory to assist in directing the organisation of the great war departments of the Government. In the result one finds also a further proof of the influence of training in engineering in ensuring efficiency in the control of Governmental affairs, and we hope that this realisation of the advantage of such training will result in the future in a wider utilisation of engineers in high national administrative posts.

Knight Commanderships of the Bath in the Civil Division have been conferred, for work at the Ministry of Munitions, on Mr. A. McDougal Duckham, who has filled many posts requiring great engineering ability and tact, and is now chairman of the Advisory Committee; on Mr. Charles E. Ellis, who has been Director-General of Ordnance Supply, having temporarily relinquished his position as managing director of Messrs. John Brown and Co., Limited, to serve the Government, and who, therefore, prior to the war, was responsible for the organisation of one of the largest of our munition manufacturing firms; on Mr. E. H. Tennyson-D'Eyncourt, C.B., the Director of Naval Construction at the Admiralty, who is directly responsible for advances in warship design which, when the story of the war can be fully told, will awaken world-wide admiration; and upon Sir Herbert Ashcombe Walker, acting-chairman of the Royal Executive Committee and general manager of the London and South-Western Railway. Another of the new K.C.B.'s is Major (temporary Lieut.-Colonel) John Norton Griffiths, D.S.O., M.P., a well-known engineering and public works contractor, who has close association with the Dominions across the seas, and has done useful military and munition service.

The honour of knighthood has been conferred upon Mr. G. T. Buckham, chief gun designer to Messrs. Vickers, Limited, who, since the war, has, for his firm, produced designs of war weapons marvellous in power relative to weight, but of which nothing further can yet be said; on Mr. W. Lorimer, chairman of the North British Locomotive Company and the Steel Company of Scotland; on Mr. V. L. Raven, chief mechanical engineer of the North-Eastern Railway Company from 1910, and since 1915 superintendent of the Royal Arsenal at Woolwich; on Mr. W. A. Tritton, managing director of Messrs. Foster, of Lincoln, who brought great practical knowledge and experience to bear in his association with Mr. Tennyson-D'Eyncourt in the design of the tanks; and on Mr. William Weir, son of one of the founders of the well-known Cathcart firm of engineers, who has done splendid service as Scottish Director of Munitions and is now a member of the Air Board. In connection with the Explosives Department, knighthoods have been conferred upon Mr. Ernest Pearson, who had charge of the construction of one of the explosive factories; Mr. H. Ross Skinner, formerly Director of Explosives Supply, and now Deputy Director-General of the Explosives Department; and on Mr. Keith William Price, Deputy Director-General of the Explosives Supply.

A C.B. has been conferred upon Lieut.-Colonel Alfred Ernest Rossignol, M.I.E.E., consulting engineer, late of the Newcastle tramways, and now of the London Electrical Engineers; and upon Colonel J. M. Denny, D.L., of the well-known Dumbarton shipbuilding firm; and a C.M.G. upon Captain E. H. Martin, Captain Superintendent of Halifax Dockyard, Nova Scotia, and the Hon. James Mitchell, Minister for Railways, Water Supply and Industries of Western Australia.

A SUGGESTED MODIFICATION OF THE WHITWORTH SCREW THREAD.

By W. C. Unwin, LL.D., F.R.S.

The need of producing a great quantity of interchangeable mechanical parts for munitions has indicated various difficulties, especially in the case of screws. In the production of screw gauges perhaps the point most prominently revealed has been the inaccuracy of lathe leading screws. There are errors due to the abutments of the leading screw, and others due to constant, or periodic, errors in the leading screw itself. Much of the error of a leading screw may be corrected by a taper bar acting on the nut. But other difficulties of obtaining interchangeable screws appear to arise from the accepted proportions of the screw thread. The following suggested modification of the Whitworth thread would remove some difficulties. No importance need be attached to the precise proportions adopted, they are merely put forward as a basis for judging what modification involves, for to form a just opinion exact figures are necessary.

The introduction of the Whitworth screw thread was one of the earliest efforts at standardisation. That it was eminently successful and practical is proved by its adoption not only in this country but abroad. Nevertheless, of late there has been an increasing tendency to make use of other forms of standard screw thread. It is believed that the International metric thread is largely adopted on the Continent, the Sellers' or United States standard thread is increasingly used in the United States, and various other forms, such as the British standard fine thread, the British Association thread, the Cycle Engineers' thread and the Automobile standard thread, are widely used in special cases. Still the Whitworth thread is not likely to be displaced from a dominant position.

For an interchangeable fit of bolt and nut on the Whitworth system the following conditions are necessary:—(1) Exactness of pitch, which ultimately depends on the exactness of the leading screws of lathes. (2) Exactness of the angle of thread, which depends on the grinding of the chasing tool. In grinding the tool point the cutting clearance angle must be allowed for, and the rounding properly effected. (3) Exactness of crest diameter. (4) Exactness of root diameter. (5) Exactness of effective diameter, on which the fit of the slopes of the threads of bolt and nut depends.

There are, then, for any screw thread five conditions on which interchangeability depends and which must be simultaneously satisfied.

The pitch and angle of thread are independent quantities, as to which no concession can be made except such a tolerance as may be decided on. In the British Standard Table the tolerance for pitch varies from ± 0.003 in. per inch in a $\frac{1}{4}$-in. screw, to $\pm$ 0.0019 in. per inch in a 3-in. screw. The tolerance on angle varies from ± 1.5 deg. on small screws to $\pm$ 0.5 deg. on large screws. With a sufficiently accurate leading screw and a properly ground chasing tool these conditions need not give trouble.

The case is otherwise with the three remaining quantities, the crest, root and effective diameters. No doubt in the case of inspectors' gauges, which must be of high accuracy, with such means of measurement as exist at Teddington the crest and root diameters can be accurately tested and the effective diameter of plug gauges. It is doubtful whether the effective diameter of ring gauges has hitherto been tested, though it can be done. But in the case of gauging work it is believed that stress is laid on crest and root diameter and the effective diameter is untested. A go and not-go

gauge tests the root and crest diameter, and at the same time the pitch, and to ease the workman's problem and facilitate passing there is a strong temptation to thin the screw threads.

But the fitting of the threads on the slopes is really much more important than the fitting at crest and root, even if that were perfectly secured, which in fact it is not, because of the tolerances.

It seems more rational to aim directly at exactness of effective diameter, and in that case much larger tolerances could be allowed on the crest and root diameters, and this would simplify the workman's task. He would require to aim at exactness on one dimension instead of on three. To make this possible an easy means of gauging effective diameters must be found. In some newer systems of screw thread a definite clearance between crest and root of engaging threads has been provided. It is believed that in the Sellers' thread as originally designed there was a clearance equal to one-sixteenth of the triangular depth of thread, or about 0.05 pitch. In text-books this thread is shown without clearance, but it is doubtful if it is made so. In the International metric thread "a feature is the introduction at the root of the thread of an extra amount termed clearance, which has been fixed at a maximum of one-sixteenth of the height of the triangular thread," or, again, about 0.05 pitch. If such a clearance is allowed the exactness of crest and root diameters becomes of less importance and larger tolerances may be allowed. On the other hand, the exactness of effective diameter, securing the fit on the slopes, becomes of more importance.

It is generally overlooked—in text-books, for instance—that in the British Standard Table a small clearance under the name of an "allowance" is provided between the crest of the bolt and root of the nut, and between the crest of the nut and root of the bolt. Thus for the 1-in. bolt the allowance or clearance is 0.0045 in. and for the 3-in. 0.0077 in. In principle, therefore, a clearance is sanctioned by the Standards Committee.

Diameter D.	Pitch. p	Clearance on Diameter 2c.	Crest Diameter.	Effective Diameter.	Core Diameter.
Whitworth Thread. Bolt.					
0.5 ..	0.0833	—	0.5	0.4466	0.3933
1.0 ..	0.1250	—	1.0	0.9200	0.8399
2.0 ..	0.2222	—	2.0	1.8577	1.7154
3.0 ..	0.2857	—	3.0	2.8170	2.6341
Modified Whitworth Thread. Bolt.					
0.5 ..	0.0833	0.0083	0.5	0.454	0.4018
1.0 ..	0.1250	0.0125	1.0	0.931	0.9525
2.0 ..	0.2222	0.0222	2.0	1.878	1.7380
3.0 ..	0.2857	0.0286	3.0	2.843	2.6025
Whitworth Thread. Nut.					
0.5 ..	0.0833	0.0007	0.5007	0.4503	0.3940
1.0 ..	0.1250	0.0010	1.0010	0.9260	0.8409
2.0 ..	0.2222	0.0014	2.0014	1.8675	1.7168
3.0 ..	0.2857	0.0017	3.0017	2.8301	2.6358
Modified Whitworth Thread. Nut.					
0.5 ..	0.0833	0.0083	0.5083	0.454	0.4100
1.0 ..	0.1250	0.0125	1.0125	0.931	0.8650
2.0 ..	0.2222	0.0222	2.0222	1.878	1.7000
3.0 ..	0.2857	0.0286	3.0286	2.843	2.6912

Fig. 1 shows the proportions of a modified Whitworth thread, in which a clearance $c = 0.05\,p$ has been allowed, the other proportions being the same as in the normal Whitworth. The rounding at crest and root is $r = 0.16\,p$; the depth of thread is $0.59\,p$; and the whole depth of triangular thread of 55 deg. is $0.96\,p$. The diameter at crest of thread of bolt = D; at root = D − $1.18\,p$. The diameter at crest of thread of nut = D − $1.08\,p$; at root D + $0.1\,p$. The effective diameter is D − $0.54\,p$.

The table in the preceding column gives some cases calculated by these rules. Although a much larger clearance is taken in the case of the modified Whitworth thread the actual differences of dimension are not great, and can be to some extent neutralised by the greater tolerances allowable.

The extreme difference in the crest and root diameters is only 5½ hundredths of an inch in the case of the 3-in. nut and is generally much less.

The Effective Diameter.—The fit of the threads on the slopes, if the thread angle be accurate, depends directly on the pitch. In the normal Whitworth thread the effective diameter is D − $0.64\,p$. In the modified thread it is D − $0.54\,p$. In the case of inspection gauges the effective diameter of plug gauges is measured by the needle method, but, so far as the author knows, the effective diameter of ring gauges is not measured. In the case of work inspection there is really no check on effective diameter, and the tendency is to make threads thin, because this masks error both of pitch, angle and effective diameter.

It is not stated clearly in the Standards Report how the tolerances on effective diameter were fixed, except the general statement that they are allowances to compensate the maximum pitch error. In the following table the pitch tolerances in the Standards Report are adopted, though the principle of making them depend on the reciprocal of the fourth root of the diameter does not seem rational. For the effective diameters those corresponding to the maximum and minimum pitches have been calculated. This gives somewhat smaller tolerances than in the report, and no importance is attached to them except as a suggestion. The pitch error has been taken for 1½ diameters :—

Diameter of bolt.	Pitch Tolerance in 1½ Diameters.	Pitch. Max.	Pitch. Min.	Effective Diameter. Max.	Effective Diameter. Min.	Tolerance on Effective Diameter.
0.5	0.0023	0.0856	0.0810	0.4563	0.4538	0.0025
1.0	0.0038	0.1288	0.1212	0.9346	0.9305	0.0041
2.0	0.0063	0.2285	0.2159	1.8834	1.8766	0.0068
3.0	0.0086	0.2943	0.2771	2.8504	2.8411	0.0093

Gauge for Effective Diameter.—Hitherto the effective diameter of plug gauges has been measured by the needle method, which is satisfactory though cumbrous. In the case of ring gauges the effective diameter has not been measured.

The gauge shown in Fig. 2 with only one turn of the screw thread would gauge directly the effective diameter of ring gauges, and can be arranged for a "go" and "not-go" gauge, leaving nothing to discretion. Having only one turn of the thread it is practically unaffected by pitch error. It gauges effective diameter and nothing else.

To construct this gauge probably a screw of three or four threads should be made and tested for accuracy, the crests and roots being cut away in chasing it. Then all the threads except one should be removed. There may be other forms of gauge to effect the same result, but they are not known to the author. A gauge on the same principle could be made for plugs, but it is less necessary.

Tolerances on Crest and Core Diameter.—At present the tolerances are very small, and are negative on the bolt and positive on the nut. Thus :

Diameter	0.5	1.0	2.0	3.0	
Tolerance on bolt ..	0.0025	0.0035	0.0050	0.0060	crest.
,, nut ..	0.0025	0.0035	0.0050	0.0060	,,
,, bolt ..	0.0032	0.0045	0.0064	0.0078	core.
,, nut ..	0.0025	0.0035	0.0050	0.0060	,,
Proposed clearance	0.0083	0.0125	0.0222	0.0286	

These dimensions are reckoned on the diameter.

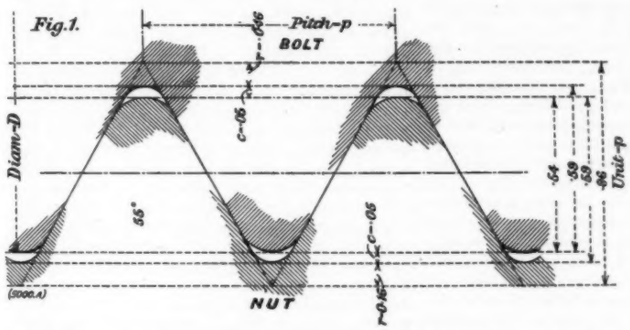
It is clear that with the proposed clearance the tolerances might be made plus or minus on both bolt and nut, which in effect is doubling them. It would be more convenient and it would seem more rational that the tolerances, like other dimensions of the thread, should be proportional to the pitch. The tolerances in the British Standard Table average about $0.025\,p$ for the crest of bolt and the crest and core of the nut, and about 0.032 for the core of bolt. As the adoption of a clearance would make the precise value of the tolerances less important, there would seem advantage in taking the tolerances uniformly equal to ± 0.03 pitch. Their values would then be :—

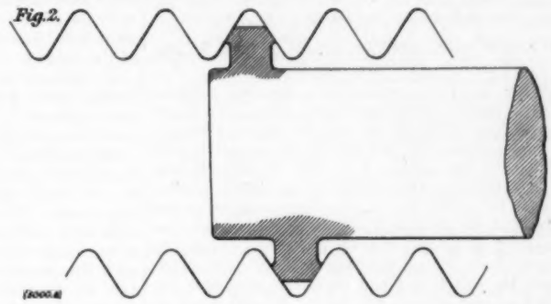
Diameter	0.5	1.0	2.0	3.0
Suggested tolerance ± ..	0.0024	0.0038	0.0067	0.0086

These are not very different from the accepted values given above.

Pitch Tolerance.—The same considerations apply in the case of the pitch tolerance. Suppose the pitch tolerance be taken at ± $0.03\,p$. The following table gives a comparison of the tolerances in the British Standard Table per 1½ diameters and values so calculated :—

Diameter	0.5	1.0	2.0	3.0
Tolerance in Table ..	0.0023	0.0038	0.0063	0.0086
0.03 p	0.0025	0.0038	0.0067	0.0086





NOTES.

ELECTRIC WELDING.

IN a recent discussion on electric welding before the American Society of Mechanical Engineers the use of electrically-welded, in place of riveted, joints for boilers was advocated by Mr. E. A. Wildt. The author stated that the success of any weld depended on bringing the metal to the proper temperature. In welding with acetylene or with the carbon arc the metal was actually melted, and suffered in quality accordingly. By using the "pencil" method of electric welding, however, the temperature need not rise above that required to render the metal plastic. In fact, so soon as the metal added to the joint reached this condition, the pencil must be advanced towards the work in order to close up the spark gap. The heat being confined to a very small area in the immediate neighbourhood of the joint, the expansion and contraction strain were small. Welds thus made had, he stated, been successfully used in making vessels of ½-in. metal, carrying a pressure of 500 lb. per square inch. The same system had also been used in constructing a small water-tube boiler, in which not a single rivet was used in the drums. Mr.

P. A. E. Armstrong, in his contribution to the discussion, observed that when the carbon arc was used for welding the metal was heated nearly as much as in gas welding. The bare-wire electric process, on the other hand, restricted, in great measure, the thermal disturbance. The deposited metal was, however, usually oxidised and distinctly cold short, with an almost complete absence of ductility. The problem was, therefore, to surround the bare wire with a slag which would prevent this oxidation. He described an electrode of English origin in which he said this aim was attained. This electrode was composed of an iron or steel core, parallel to the axis of which was also laid a very thin wire of aluminium. The function of the aluminium was to purify the metal as melted. The whole of the wire was next covered with a braided slag. In use, the current passed through the core, forming an arc between it and the work in hand. This arc fused both the core and the outer slag covering. The consequence was that the arc was formed in the slag vapour and not in the open air. The fused metal as it flowed into the joint was at all times covered with a thick layer of slag, which both localised the heat and insured the complete fusion of all the metal in its vicinity. There was, he said, no tendency for the slag to become entangled in the weld, since it was much lighter than the metal and had no affinity for it.

Self-Induction, the Movement of the Earth, and the Æther.

When a wire is moved in a magnetic field, an electric current is induced in the wire. The observation does not teach the experimenter anything as to any influence of the motion of the earth with respect to the æther. The case of self-induction looks different. The carriers of an electric current flowing in a wire, Dr. A. von Schütz argues in the *Physikalische Zeitschrift*, of August 15, 1916, are supposed to be the moving electrons. When the current flows in the direction of the motion of the earth, the velocity of the electrons, relative to the æther at rest (r.t.a.), will be V, V being equal to $v + w$, where v is the velocity of the earth (r.t.a.) and w the velocity of the electrons relative to the wire (r.t.w.). When the wire is turned through 180 deg., so that the current flows with the same intensity in the direction opposite to the motion of the earth, the velocity of the electrons (r.t.a.) will be $V = v - w$. The same diminution of the velocity (r.t.a.) can be produced by leaving the wire at rest, but stopping the current, when $V = v$, and then restarting the current in the opposite direction, when $V = v - w$. Now the question of the magnetic field created by the current enters. If that field depended upon the velocity of the electrons r.t.a., the turning of the wire (about 180 deg.) should alter the velocity of the electrons r.t.a., and thus the magnetic field itself, and a self-induction should be set up, as in the case of the current reversal in a wire. If the motion of the electrons r.t.a. were the decisive factor, any alteration of this velocity should set up self-induction. In reality, however, self-induction is only observed in one case, viz., when the velocity of the electrons relative to the wire (r.t.w.) is changed. This fact can only be explained by the assumption that the magnetic field is induced by the motion of the electrons r.t.w., not by the motion r.t.a.; for the turning of the wire does not affect the magnetic field, provided the current intensity, *i.e.*, the velocity of the (negative) electrons with respect to the positive electrons, remains unchanged. Even when the current is stopped and reversed, alteration of the magnetic field and the appearance of self-induction may be prevented by bifilar winding. Thus, Schütz concludes, the magnetic field must be due to the movement of the electrons with respect to the wire, and the movement with respect to the æther is not concerned. The fundamental question whether the æther is at rest, or whether the assumption of an æther might be abandoned, would remain open as before.

Recent Physiology and the War.

Discoursing upon "Recent Physiology and the War" at the Royal Institution on Friday, February 2, Professor C. S. Sherrington, F.R.S., referred first to some problems which are only indirectly connected with the war, though the war has heightened their importance. His first point concerned hours of work, fatigue and output. Men were tested who had to make screw threads in shells by turning a tap wrench; it was hard work, but these men, as the other workers to be mentioned, were well taken care of in well-appointed works. The output curves obtained agreed with the laboratory fatigue curves. The average output was poor in the first hour, but rose steadily, to drop off again a little just before dinner time; the afternoon curve was similar. When the actual working hours were reduced from 62 to 56, the curves did not alter in shape, but the output was raised by 6 and more per cent. In the second case mentioned women had to turn aluminium fittings on the lathe, fairly hard work; the actual hours—68 originally, with one Sunday off every four weeks—were reduced in three steps to 59, 54 and 51 hours, and the output increased in the inverse ratio, by 14 per cent. finally. In his second point Professor Sherrington dealt with alcohol. Groups of men, mostly below 30 years of age, engaged in office work, not total abstainers, were given the equivalent of 30 cub. cm. of alcohol in 120 cub. cm. of water at 6 p.m. on certain days, and afterwards submitted to various tests during a period of 1½ hours. There were thus alcohol days and non-alcohol days; it was found impossible to keep the men in ignorance as to the administration of the alcohol; some of the tests were, however, hardly influenced by the will of the subject. The knee-jerk, and the closing of the eyelids when the subject was startled by a sudden noise, were delayed by alcohol; when the men were asked to move their fingers as rapidly as possible, as in piano-playing—they were not players—the rapidity of this voluntary action was delayed by alcohol, and the energy distinctly diminished, as had been the case with the automatic reflex movements. Thus alcohol diminished the working capacity; at the same time alcohol enabled a body to do temporarily with less food, but it interfered with the machinery, whilst sugar stimulated and did not interfere. Professor Sherrington did not express any final opinion as to total abstinence. His other remarks bore directly on war problems, and were intended to show that physiologists had not discontinued their investigations. One of the questions he discussed was how to meet the dangers arising from severe loss of blood. The circulation of the blood depended, he said, as much upon the elastic contractions of the blood-vessels as upon the pumping action of the heart; the contraction failed when the blood-vessels were only half full. These vessels might be refilled with blood by transfusion—a risky experiment requiring elaborate preparation—or also be refilled with "saline solution." That solution did not bring the blood pressure up to its full value, however; but by adding a viscous material, gelatin, *e.g.*, to the saline solution, the osmotic pressure of the blood could be adequately raised. We should add that Professor Sherrington took the place of Dr. Charles Carpenter, who was prevented from delivering his announced discourse.

French National Laboratory for Physical and Mechanical Research.

In an interesting article published in *Le Génie Civil* Mr. H. Le Chatelier reviews in detail the scheme of the French Academy of Sciences for the formation of a national laboratory for physical and mechanical research. He states that for a century there has been a profound disagreement in France between the political *régime* and the habits and customs of the inhabitants. Like England, France has a democratic Government, but, unlike England, France has kept up monarchical prejudices, and unceasing collisions take place owing to this fact. Frenchmen still consider the State as an emanation of the divinity and rely upon the State to settle all questions of general interest; they have not yet understood that in a democratic State the function of Government must be limited to insuring to each and every one the liberty of living and working for the best of his personal interests and conveniences, on the sole condition of not infringing on similar rights owned by his neighbours. In England, every well-bred man does not think he has fulfilled his duties to his country when he has devoted his energies to his own private occupations. He considers himself bound to devote also a part of his time, activities and money to the public interest, and, among other matters, he takes an active part in the work of the technical societies of which he is a member, a proof of this being afforded by the very interesting discussions at the meetings of such societies; he considers the interests of the Empire to be also his own, and believes that the best way of defending them is to deal himself with them. As examples, Mr. Le Chatelier states that Sir Robert Hadfield, whose works occupy 16,000 operatives, spends probably half his time in the study of problems of scientific organisation and economics; Sir William Beardmore devises means for obtaining collaboration between university laboratories and those of the works, and constitutes himself as a determined champion of scientific research. Further, the series of conferences held in favour of compulsory military service by Lord Roberts, at a time when he was over seventy years of age, will be fresh in the mind of everybody. The essential aims of the proposed laboratory would be the carrying out of systematic research on rigorously scientific lines and directed towards useful industrial ends. As a type of such, Mr. Le Chatelier instances the remarkable researches by Regnault on the properties of elastic fluids. He also calls attention to the systematic work carried out by the National Physical Laboratory and by the Washington Bureau of Standards. Certain classes of work might be provisionally and partly left on one side in the organisation of the proposed French Laboratory, electricity, for example, owing to the existence of the laboratory of the Société Centrale des Electriciens, and the testing of structural material, which is dealt with by that of the Conservatoire des Arts et Métiers. The main point to be kept in mind with reference to the satisfactory working of an organisation such as the one contemplated, and the most difficult point to meet, according to Mr. Le Chatelier, is the selection of subjects for *étude*. Engineers and technical men are rarely interested in elementary phenomena, the investigation of which would be most conducive to the development of their industry; whilst, on the other hand, the learned men, being insufficiently instructed in regard to practical problems of everyday life, may, on their part, find it difficult to make a selection. It is the admirable way in which Professor Glazebrook has directed the work of the National Physical Laboratory which has earned for this establishment the reputation it has acquired both in industrial and in scientific centres. In the matter of the proposed French laboratory, the Académie des Sciences proposes to entrust the initiative in this respect to a small committee of at most five members; the Académie would be responsible for the selection of the members of council and for the appointment of the director. Its intervention would then cease, and the laboratory henceforth would be an independent institution.

Problems of Aeronautics.—Addressing the National Academy of Sciences at Boston, Mass., last November, Colonel G. O. Squier, of the U.S.A. Signal Corps, gave a summary of some aeronautical problems which require further investigation. Having referred to aerodynamics, he passed to engine problems, pointing out that a more efficient fuel was needed; experiments with various combinations of alcohol, gasoline, acetylene, hydrocarbons, picric acid, &c., had been unsatisfactory; the fuel should be solid, to prevent leakage of stored liquid fuel, but convertible into a liquid just prior to use; the fuel tubes and tanks should resist rupture, and might possibly be made of fabric and rubber, which would withstand vibrations better than metal. The tanks should also be bullet-proof, so that holes made by bullets would close automatically. A rust-proof coating for metals was needed; baked enamel was good, but not always applicable. The noise made by the engines should be suppressed. A strong, transparent, fireproof wing covering was wanted. Radiotelegraphic and photographic apparatus for aircraft required improvement. An important physical question was the structure of gusts and the exploration of the eddies produced when the wind struck trees, cliffs, hollows, &c., or swept over swamps and deserts. The elasticity of the air and the friction between the air and objects moving at high speeds should be further studied. A gramme of matter moving at 25 miles per second had a kinetic energy of 8.0937×10^{12} ergs, sufficient to lift a ton of matter to a height of 298 ft. and sufficient to explain the tremendous force of cyclones. It was, further, not unlikely that vibrations took place in the air at high frequencies of 100,000 periods and more, vibrations no more suspected than the electromagnetic waves had been suspected before Hertz devised a detector.

LITERATURE.

Welfare Work. Employers' Experiments for Improving Working Conditions in Factories. By E. DOROTHEA PROUD, B.A. (Adel.), with a foreword by the RT. HON. DAVID LLOYD GEORGE, P.C., M.P. London: G. Bell and Sons, Limited, 1916. [Price 7*s.* 6*d.* net.]

IN these days when the relations between capital and labour are scrutinised most narrowly and many are eager to foster permanent good feeling and happier social conditions among all classes of workers, Miss Proud's book should arrest attention, though it deals with only one part of a great question and its treatment as well as the conclusions drawn refer almost exclusively to female labour. But as Mr. Lloyd George reminds us in an appreciative and stimulating preface, the advent of women into a class of factories from which they have been hitherto excluded, due to the necessities of the war, is fraught with important possibilities, and the far-reaching results of the movement are not yet adequately apprehended. Owing to the urgency of the crisis, women in their thousands and hundreds of thousands have willingly accepted discipline, have submitted cheerfully to long hours, to hard work, to monotonous work, but in so doing have introduced a new and perplexing factor into a problem already sufficiently complicated. The overwhelming nature of the change occasioned by the eager response has widened the outlook and the opportunities of the welfare worker, but it would be to travel out of the record to discuss whether the altered conditions will prove temporary or permanent. It is sufficient to say that Miss Proud has served in the Welfare Department of the Ministry of Munitions since its foundation, that her views have been corrected or strengthened by actual contact with the lives and hardships of workers under varied conditions, and that, owing to her wide experience, she is entitled to the gravest respect.

Her object is to examine the methods adopted or advocated for improving the conditions of employment in factories, to inquire into the success that has attended the voluntary efforts of employers, the direction in which further efforts may be profitably made, and the obstacles that limit wider action. To those who are only superficially acquainted with the relations between workers and employer, or those who allow their kindly feelings to outrun their reason, the problem may appear easy of solution, and that an adequate remedy is to be found in the exercise of some greater generosity on the part of the employer, and some curtailment of the arbitrary authority that the capitalist is supposed to wield. We hope that Miss Proud's book will at least be able to disabuse those good-natured souls who believe that the amelioration of a grievous sore that cuts deep into the social fabric can be remedied by any simple means. Improvement, to be effectual, must be proportioned to the severity of the evil it seeks to remove.

Labour has urged very forcibly that the power of capital in the hands of employers is used in a selfish and covetous manner, destructive of any common interest that might otherwise exist to the advantage of both parties to the contract. This anti-social opposition between the workman and his employer has been fostered to such a degree that its continuance is regarded as binding as a religious rite that neither is able to mitigate or abolish. To suggest possible improvements is regarded by employees as treachery to fellow workmen and disloyalty to trade unionism: to attempt to construct a bridge of sympathy between employers and employed is defeated by a fear that its object is to increase profits or secure a larger and speedier output. Miss Proud reminds us more than once that the workpeople regard with suspicion and distrust every proposal that comes from interested employers. Charity or philanthropy is abhorrent to the British workman. "Enlightened self-interest" on the part of the employer is less distrusted, but it calls for no gratitude and awakens no sympathy. This attitude of aloofness hampers the humane employer in his well-intentioned plans for betterment, but supplies the welfare worker, independent of both parties, with a *raison d'être* and opportunity for benevolent interference.

Not the least difficulty in the way of promoting greater confidence between the employer and his workers is the fact that concessions, whether by the removal of unfavourable, or the gift of specially favourable, conditions pay, that is, add to the employer's profits. Robert Owen, a century ago, showed that improvements in the condition of work and habits of life were not incompatible with commercial success, and the truth has been amply demonstrated in many ways since. The whole trend of industrial legislation, urged in the interests of labour, has, it is true, benefited the nation socially and economically, but could not have been carried to a successful issue if the country had not been convinced that prosperity, national and individual, would follow from a more generous treatment of the working class. Some employers, as the author justly points out, have gone far beyond legal requirements in their thoughtful provision for their workpeople, but though these have been actuated by the most unselfish motives and could not foresee that their generosity would operate to their advantage, there need not be any question of philanthropy on the one hand, or the acceptance of charity on the other. In such cases welfare work can come to the assistance of the employer, and in this connection be it remembered schemes of profit-sharing and co-partnership, that in some instances have been aggressively advertised, have no place.

Viewed in the light of mutual benefits, the interests of employer and employed seem to be identical, and so far that each live and thrive by production, there is a harmony of interests which might induce both to work for a common end. The welfare and increase of business, the profit of the owner, as an argument for the better regard of the environment of the worker, is one that might be expected to appeal to the worst class of Texan cotton planters in the old slavery days. It would, however, be ineffective without sympathetic guidance, and, on the other side, the British workman sees in the suggestion of the "Welfare of the Business" the possible merging of his own personal interests and the loss of individual freedom that would work to the detriment of himself and his class. Looking beyond the immediate present, he may object to being trained into a more perfect animal simply that he may prove a better productive machine. The interests of employer and employed approach each other, but are not identical, and hence the necessity for ameliorative legislation which otherwise would be unnecessary. The conflict of interests is more patent than the harmony, and in this conflict passion and prejudice are often more evident than rational self-interest. Miss Proud, if we understand her correctly, dreads the paralysing effects of easy contentment and emphasises the importance of the spark of "divine discontent," as a stimulant to induce the employed to struggle to a higher level, to keep alive the yearning towards a better condition, and to provoke more adequate opportunities for self-realisation.

Discontent may, however, become a menace as well as an inspiration, and some machinery is necessary to guide inchoate ambition and ensure the smooth working of a very complicated organisation. The welfare worker supplies in some measure this mechanism, a device that is necessarily imperfect in its action, for it is not automatic or uniform, being actuated by the capacity and swayed by the caprice of the individual. If, however, too much is not expected from the adoption of the arrangement, and we are content to await its gradual improvement by time and experience, its operation should prove beneficial.

Can we find or can we train officers who are capable of fulfilling the difficult task imposed on the welfare worker, of promoting mutual confidence and better understanding between employers and workers? Miss Proud indicates the duties of the post, its aims and its responsibilities, its demands and its rewards. By this last term is meant its possibilities in increasing industrial efficiency, in removing the drawbacks under which labour suffers, and freeing capital from the anxieties to which it is exposed. We understand that the Universities hold classes in welfare work as a branch of social economy, and are willing to train men and women to fill the positions that await those who are willing to thrust themselves between the upper and nether millstones of capital and labour. It can be no light task to deserve and enjoy the confidences of both parties, and ensure the smooth working of the industrial machine. The reluctant and possibly impecunious employer has to be urged to a keener appreciation of the legal minimum of his obligations; the discontented proletariat has to be restrained in the too eager demand for improvements that the more liberal-minded have conceded in advance of legal requirements. Responsibility there is in plenty, but no power of initiative to remove the deadweight of custom long acquiesced in, save one's force of character, possibly backed by local public opinion. There should be, too, in the efficient welfare worker a competent knowledge of the class of work performed in the factory, lest cunning impose on ignorance. With character and loyalty, there must be a kindly understanding of the workers, without any maudlin sentimentality, and a ready helpfulness without undue interference. Towards the management, there must be the exhibition of respect without obsequious cringing, and tactfulness without servility. Truly who enters on this thorny path must proceed warily. Mr. Lloyd George knows the kind of collaborator that is of assistance, and we cannot do better than quote him: "If chosen with due regard to personality, experience and character, it was found that a Lady Supervisor could relieve the management of a mass of minor but important detail. She heard complaints and investigated dismissals. She supervised the canteen and other accommodation. She helped to engage new labour. The character and tone of the workers depended largely upon her. The foremen referred to her in matters of discipline, slack work, or bad time-keeping. The workers brought their troubles to her. The management found that her presence conduced to smooth working and increased output." When such a person is found we have a pearl beyond price, and, whether man or woman, is of the salt of the earth. If it is possible for Universities to train such officers they will render a real service to industry, and if any one thinks that they have the natural gifts that by training and exercise will bring peace into business organisation and benefit both employers and employed, they cannot do better than study and digest Miss Proud's book as a first step. She looks at the subject from many points of view, and has many edifying things to say. She has seen the working of the system both in England and Australia, and knows its capacities and its limitations. Her outlook is not confined to particular instances, though she has studied in many factories, but is as wide as the nation's interests and keeps these steadily in the forefront. Industrial environment as a whole and its betterment on broad lines engross her entirely. She discusses many details that affect the lives and well-being, physical and mental, of operatives as well as those sources of friction that so frequently lead to industrial disputes, but everywhere she has in mind the furtherance of the conditions that exalt a nation.

BOOKS RECEIVED.

An Almanack for the Year of Our Lord, 1917. By JOSEPH WHITAKER, F.S.A. London: 12, Warwick-lane. [Price 3*s.* 6*d.* net.]

Annuaire pour l'an 1917, *publié par le Bureau des Longitudes. Avec les Notices Scientifiques.* Paris: Gauthier-Villars et Cie. [Price 2 francs net.]

Willing's Press Guide and Advertisers' Directory and Handbook, 1917. London: James Willing, Limited. [Price 1*s.*]

The Railway Carriage and Wagon Builders' Pocket-Book and Diary, 1917. London: The Locomotive Publishing Company, Limited, 3, Amen Corner; Calcutta: *The Indian Railway Gazette.* [Price 2*s.* 6*d.*]

Lockwood's Builders', Architects', Contractors' and Engineers' Price Book for 1917. *A Comprehensive Hand-Book of the Latest Prices of Every Kind of Material and Labour in Trades connected with Building, including Many Useful Memoranda and Tables.* Edited by R. STEPHEN AYLING, F.R.I.B.A. With a Supplement containing the London Building Acts, 1894 to 1909, By-Laws, Regulations, Legal Decisions, and an Index to Acts and Regulations. London: Crosby Lockwood and Son. [Price 4*s.*]

The British Dominions Year Book, 1917. Edited by EDWARD SALMON, F.R.C.I., and JAMES WORSFOLD, F.C.I.S. London: The British Dominions General Insurance Company, Limited, Royal Exchange-avenue, London.

Germany's Commercial Grip on the World: Her Business Methods Explained. By HENRI HAUSER. Translated by MANFRED EMANUEL. London: Eveleigh Nash Company, Limited. [Price 5*s.* net.]

THE LONGITUDINAL STRENGTH OF GUNS.

To the Editor of Engineering.

Sir,—Guns, like all other vessels subjected to internal pressure, have to resist a radial as well as to a longitudinal stress, *i.e.*, the thickness of their walls must be proportioned both to the stress which tends to break them along longitudinal sections, and to that which tends to pull them apart along sections normal to the longitudinal axis.

Now, it is really surprising that, while so much work and thought have been expended in the last 30 years to find out formulas for the calculation of all elements having reference to the tangential resistance (against the radial stress), *i.e.*, hoop thickness, shrinkage, wire, winding tension, &c., very little attention has been paid to the origin of the longitudinal stress in firing guns, and consequently, to the principles on which the longitudinal strength must be calculated.

In fact, while most of the published works dealing with gun construction give very prominent place to the theoretical derivation of the formulas for the calculation of the radial resistance, little more than a passing glance is given to the study of the origin of the longitudinal stress and to its distribution on the parts composing the gun itself.

So much so, indeed, that the present formulas given for this purpose in all text-books, to my knowledge, seem to me to be founded on an entirely wrong principle.

It is easily admitted that the reason too often given to justify such casual attention being paid to the longitudinal stress (L.S.), "That when sufficient wall thickness is given to resist the radial stress, the L.S. is also more than provided for," does not hold good for all guns composed of several layer of hoops or wire-wound, *i.e.*, practically all modern guns—since only a limited part of the hooped thickness—and none of the wire—share in the longitudinal resistance.

The convenient proportion of the several layers of hoops and their proper interlocking to provide against the L.S. can only be determined when an exact knowledge is obtained of its intensity and distribution along the interlocking parts of the gun.

The principle hitherto accepted is that the gun can be considered as a closed vessel subjected to a static internal pressure, the intensity of which varies along the longitudinal axis from breech to muzzle (from P to p, in Fig. 1).

Consequently each normal annular section, XX, considered must resist a total longitudinal pull equal to the value of the internal pressure p, corresponding to that section, by the area of the bore A. The condition of equilibrium is then considered to be

$$\frac{A \times p_i}{\frac{\pi}{4}(d_e^2 - d_i^2)} < \text{tensile elastic limit of the material.}$$

where d_i and d_e are the internal and external diameters of the annular section XX. or the two diameters of the interlocked part of it, in the case of a composite gun.

The same calculation applies to all sections comprised between breech and muzzle, so that from the curve of the internal pressure P–p it is possible to calculate the corresponding curve of the L.S. imposed on each and any section along the whole length of the gun.

But, as a matter of fact, a gun cannot be considered as a closed vessel. Because, although on the breech side the block is firmly connected to the gun, and transmits to it the full longitudinal pull P × A, from the muzzle side there is no mechanical connection whatever between gun and shell to transmit the necessary reaction in order to have on the gun walls any longitudinal stress.

The only connection on this side between gun and shell is the resistance opposed by the copper band to be crushed by the rifling; but this is only initial during the indentation of the copper band, and is certainly of a much smaller order of magnitude than the stress now under consideration. That the longitudinal pull applied by the breech block to the gun walls is not reacted by the powder pressure on the shell base is rendered evident by the fact itself of the gun recoil during firing, and in the calculation of the intensity of the gun recoil energy no consideration is practically taken of the forward pull transmitted by the shell copper band to the gun.

But if we consider the dynamic phenomenon of the gun recoil, instead of the static internal pressure alone, the origin of the reaction to the longitudinal pull of the breech block, giving rise to the L.S. in the gun walls, is easily explained.

During the combustion of the propelling charge the internal pressure acts against the breech block inner face, and this transmits the stress to the gun. The gun, thus forced to recoil briskly, opposes the inertia due to all its weight, and the L.S. so engendered in the gun walls is nothing but the transmission along all the gun length of the force which tends to pull back all the parts composing the gun itself.

We will consider a hypothetical gun of unitary bore section area—A = 1—(Fig. 2) subjected to a constant internal pressure, P P, the wall thickness required by the radial stress will then be constant from breech to muzzle.

The L.S., considered on the hypothesis of "statical pressure in closed vessel," would be equally constant all along the gun, and could then be represented by the same line P P (being A = 1).

Subsequently we will consider the dynamic condition of the same gun subjected to the same internal constant pressure P P, on the hypothesis of the L.S. being generated by the inertia of the gun parts to recoil, and will calculate the intensity of the L.S. for the sections corresponding to four equidistant normal planes, A B C D.

W = the total weight of the gun.
w = the weight of the breech block and gun part on the left of plane A.
$W_A = W - w$, the weight of the gun part remaining on the right side of the plane A.
$W_B = 2/3\ W_A$, the weight of the gun parts remaining on the right side of plane B.
$W_C = 1/3\ W_A$, the weight of the gun parts remaining on the right side of plane C.
$W_D = 0$.

The total pressure P, acting against the breech face, is counteracted by the inertia to recoil of the total weight W. Then the fraction of this pull (L.S.$_A$ on section A) counteracted by a weight $W - w = W_A$, must be in the same linear proportion to the total value P as W_A is to W, *i.e.*:

$$\frac{L.S._A}{P} = \frac{W_A}{W} = \frac{W - w}{W}$$

and then:

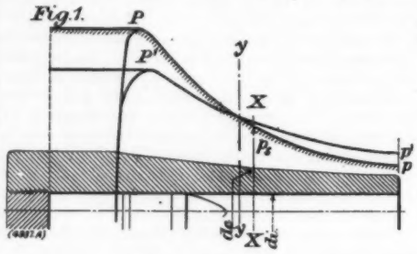
$$L.S._A = P \times \frac{W_A}{W} = P \times \frac{W - w}{W}$$

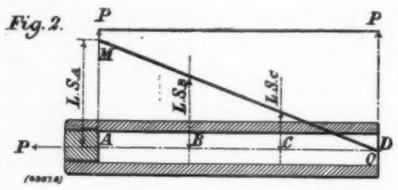
Similarly the L.S. for sections B and C will be:

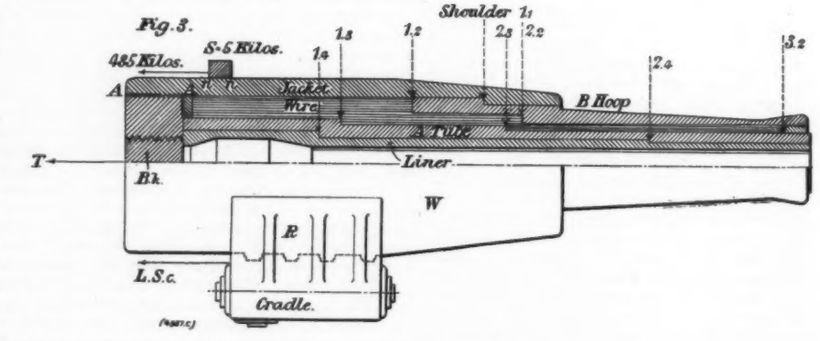
$$L.S._B = P \times \frac{W_B}{W} = P \times \frac{\frac{2}{3}(W - w)}{W}$$

$$L.S._C = P \times \frac{W_C}{W} = P \times \frac{\frac{1}{3}(W - w)}{W}.$$

The values L.S.$_A$ — L.S.$_B$ — L.S.$_C$ — L.S.$_D$ are in linear proportion; the straight line M — O will then represent graphically the decreasing value of the L.S. for all the sections between breech and muzzle.







It will be noted at once that the line M — O differs materially from the horizontal line P P taken to represent the constant L.S. for the same sections, calculated when the gun was considered a closed vessel, subjected to statical internal pressure.

The following are three fundamental differences from the previous conception of the conditions under which the L.S. is applied to the gun walls:—

(1) The maximum L.S. acting on all sections of the gun between breech and muzzle is a function of the maximum pressure in the chamber P, and is independent of the decreasing values of this pressure along the curve P. p_s. p (Fig. 1). For instance, the maximum L.S. on the section XX is a linear function of P and not of P_s.

If, in the gun considered in Fig. 1, by the use of a slower burning powder a new pressure curve were obtained (P' p'), it would seem, by deduction from the theory of the static pressure in closed vessel, that the L.S. should be decreased for the sections on the breech side of the plane Y Y, and should be increased for those on the muzzle side of it. Instead, since the maximum L.S. of all sections is a function of the highest value of P, all the sections between breech and muzzle would be subjected to a lower L.S.

(2) All the normal sections between breech and muzzle are stressed to the maximum of their corresponding L.S. contemporaneously when the internal chamber pressure reaches its maximum value P, and not when the internal pressure reaches, with the shell base, the section considered. (For instance, all sections of the chase are stressed longitudinally to their maximum when the shell base is but a few calibres from the start, and, therefore, when there is not yet any internal pressure on them at all).

(3) The weights attached to the gun during recoil (gun cradle, recoil cylinder or piston, springs, or running-out cylinders, &c.), all concur in opposing inertia to the recoil, and must be taken into account in the calculation of the distribution of the L.S. on the various parts of the gun itself.

The consideration (2) may explain the known tendency in thin liners of long guns to elongate towards the muzzle, crushing the shoulder when they are not of sufficient area. This appears natural when we consider that the liner part which is on the gun chamber is firmly kept in place by the friction generated by the high internal pressure pushing it against the A tube. The remaining two-thirds of the total liner length, instead, are stressed longitudinally to their maximum before the internal pressure reaches them, so that the friction against the A tube (if any) is of a very much smaller order. It is, then, quite possible that the considerable weight of the chase part of the liner reacting to the recoil on the resistance offered by the annular section of the intermediate part may generate some permanent set, tending to increase the length of the liner, with the consequent crushing of the front shoulders and the well-known and dangerous contracted rings inside the rifling.

The general longitudinal strength of a composite gun depends on the strength of the joining of the various hoops and tubes to the breech block, and can be calculated on the basis expounded above.

We will consider only the distribution of the L.S. on the shoulder planes, where the L.S. is transmitted from hoop to hoop. It is understood that, knowing the distribution in these points, the general calculation for the shoulder shearing and crushing and hoop tensile stresses will proceed on the normal lines already followed at present.

In Fig 3
T = the total pull, in tons, corresponding to the action of the internal pressure against the inner face of the breech block, of bore section area;
W = the total weight, in tons, of the gun, and
R = the weight of the recoiling parts connected to it (cradle, recoil cylinder or piston, running-out cylinders or springs, rods, &c.);
L — A — W_l — B — J — B k = the weight, in tons, respectively, of the liner, A tube, wire, B hoop, jacket and breech block and ring.

The L.S. on the threaded surface A A will then be:

$$L.S._{AA} = T \times \frac{\text{weight of parts opposing inertia on AA}}{\text{total weight of recoiling parts}} =$$

$$T \times \frac{L + A + W_l + B + J + R}{W + R} = T \times \frac{(W + R) - B_1}{W + R}$$

The corresponding L.S. for shoulder 1_1 will be:

$$L.S.1_1 = T \times \frac{L + A + W_l + B}{W + R}$$

The sum of the L.S. on shoulders $1_2 + 2_2 + 3_2$:

$$L.S.\ 1_2 + 2_2 + 3_2 = T \times \frac{L + A + W_l}{W + R}$$

For shoulders $1_3 + 2_3$:

$$L.S.\ 1_3 + 2_3 = T \times \frac{L + A}{W + R}$$

For shoulders $1_4 + 2_4$:

$$L.S.\ 1_4 + 2_4 = T \times \frac{L}{W + R}$$

and for the connecting points of the cradle to jacket:

$$L.S._c = T \times \frac{R}{W + R}$$

In this way it is also possible to calculate the stress exerted on the points of attachment of any part fixed to a

recoiling gun. If s is the weight of the attached part the stress on the point of attachment is $T \times \frac{S}{W+R}$ where TW and R are as above.

Example—In a gun the total weight of the recoiling parts of which is 6 tons, the shearing stress exerted along plane *nn* (Fig. 3) of attachment of a part weighing 5 kg. would be (for a value of T = 550 tons):

$$L.S.s = 550{,}000 \times \frac{5}{6{,}000 + 5} = 485 \text{ kilos.}$$

The calculation of the distribution of the L.S. in unshouldered guns (*i.e.*, with whole conical inter-hoop surfaces) does not lend itself to such a simple treatment, but the general principle evidently still holds good also in this case for the calculation of the total pulls between the several hoops and layers of wire, however connected.

Yours truly,
M. CANDELERO,
Civil Technical Staff, Royal Italian Navy.
London, February, 1917.

THE STANDARDISATION OF THE MARINE ENGINE.

To the Editor of Engineering.

SIR,—With reference to the standardisation of the marine engine proposed by the North-East Coast Institution of Engineers, while it is not disputed that such a scheme merits most careful consideration, it may be questioned if it is being gone about in the best way. In the first place, it should be apparent that it is much too big a scheme for any single Institute or district to carry through successfully. What is wanted is a specification embodying the best features of all districts, and based on the experience of builders and owners, with the help of the various registration societies. In short, a representative commission should be appointed to deal with the question, receiving and considering all kinds of evidence. To the writer, who has been an advocate of the standard engine for a number of years, it appears a matter for regret that a start was not made by setting down the dimensions of a series of engines. A glance at the following table will show what is meant, and where the trouble lies.

Stroke in Inches.	Variation in Diameter of High-pressure Cylinder. Inches.	Remarks.
48	20 to 30	
45	20 to 28	
42	17 to 26	
39	18 to 25	1 at 10.66.
36	17½ to 22	3 at 15½ in., 3 at 24 in.
33	15 to 20	4 at 12 in., 4 at 24 in.
30	13½ to 19	
27	11 to 18	
24	10 to 16½	1 at 19 in.
21	9 to 13	
23	9 to 14½	
22	9 to 13	

This Table has been prepared from particulars taken from Lloyd's Register, and covers the practice of the past twenty years. Some 6,000 engines are dealt with, and little consideration will be required to satisfy anyone that a needless amount of overlapping has taken place in the past. An attempt should be made to get rid of this. The range of powers used in the majority of cargo vessels is from, say, 500 to 2,400 i.h.p. (at sea); above this we get into the range of the quadruple or geared turbine. That being so, if these powers are divided by steps of 200 h.p., about ten different sizes of engines would cover the whole range, and even less would do it if a small variation of the boiler pressure and the other factors included in the "Plan" formula were made use of. All centres and other dimensions dependent upon them would then be fixed; condensing surface and pump capacity would follow. The advantage would be that the builder could specialise on production, with a consequently reduced first cost. Whether the scheme can be extended to include auxiliaries and boilers satisfactorily may be questioned, unless the ship is standardised as well. A lot of prejudice has to be overcome if it is to have the success it deserves, and the authors would be well advised to go further afield for support than they appear to be doing at present.

I am, yours truly,
WM. M'ARTHUR MORISON.
113, St. Vincent-street, Glasgow.
February 12, 1917.

WORM GEAR AND WORM GEAR MOUNTING.

To the Editor of Engineering.

Sir,—I note, appended to the latter part of my paper, republished by you, on "Worm Gear and Worm Gear Mounting," you have given a "speech" made by Mr. Francis J. Bostock, which followed the reading of the paper. The speech appears to be mainly, if not entirely identical with a written communication contributed by Mr. Bostock to the paper which I have received from the secretary, and to which I have given a reply. The reply will duly appear in the Proceedings of the Institution, and when it has thus appeared I am sure the council will have no objection to its republication in your columns. It will suffice to remark for the time being that in my opinion Mr. Bostock is entirely mistaken in his contention as to rolling action taking place in lieu of sliding or rubbing. In point of fact the extent of the sliding or rubbing action in gears of different types, whether spur gear or worm gear, of any given ratio, is dependent wholly and solely on the position of the point of contact at any instant in relation to the gear axes, and upon nothing else. A simple proof of this fact will appear in my contribution to the Proceedings as above stated. If my contention in this matter is correct, the main burden of Mr. Bostock's communication is an exposition of fallacy. Beyond the above, I disclaim entirely Mr. Bostock's assertion that "Mr. Lanchester himself seems to be disappointed with the photographs." The photographs, as photographs, are satisfactory and conclusive, the only feature in which they may be considered unsatisfactory is that they are not so well contrasted for half-tone reproduction as the printer could wish. A striking proof of the accuracy of these photographs is the complete harmony between the lay-out of the tooth sections on a cylindrical section as reconstructed from the plane sections, and the actual cylindrical section of the gears made subsequently.* There can be no question of the satisfactory character of photographs which show such complete agreement.

Mr. Bostock finishes his note with a challenge; my reply is as follows:—There is a dynamometer built by the Daimler Company to my design which has been certified by the National Physical Laboratory to give results within one-fifth of 1 per cent. That dynamometer has been presented to the National Physical Laboratory, and is at Teddington. After the war it will, I understand, be available in the ordinary course of business for testing right angle-transmission for any firm who requires such work. The National Physical Laboratory's fees are moderate, and their report is regarded by most educated people as conclusive. The Lanchester gear has been submitted to severe tests by that dynamometer under the supervision of the National Physical Laboratory. The results have been published as a report, and will be found incorporated as Appendix I to an earlier paper on "Worm Gear" (Proceedings Inst. A.E., page 242, vol. vii). It is open for Mr. Bostock, or Messrs. David Brown and Son, or anybody who after the war wishes to have authentic figures as to their gear efficiency or endurance to arrange for such tests as they require, and the report of the National Physical Laboratory may always be published, provided that it is published *in toto*, as in the case of the report on the aforesaid test of the Lanchester gear.

There is no need for the brandishing of swords or the issuing of challenges. My own gear has been put through the ordeal, and any other manufacturer who cares to face it may do so without fear or favour.

Yours faithfully,
F. W. LANCHESTER.
53, Hagley Road, Birmingham, February 13, 1917.

"SKILL AND PAYMENT."

To the Editor of Engineering.

SIR,—I shall be obliged if you will publish the following reply to your leading article in your issue of February 2.

Although admitting the undoubted skill, &c., of the toolmaker, I am at a loss to understand why he should be coupled with the draughtsman, who is, by reason of his technical education and special training, &c., on a different footing altogether. It would be a fairer basis to couple the draughtsman with the manager. No doubt if the draughtsman obtained a slightly larger salary than the manager it would rather upset the leading article referred to as regards comparisons of salaries, &c., and there would be a very general feeling that the manager would have some cause for grievance and would certainly air it.

To compare one business with an entirely different business as regards salaries would not appear to bring much satisfaction to those concerned. The draughtsman is an entirely indispensable man to the working of any progressive factory. He has to possess vast experience by years of training and study, is often called upon to deal with business matters quite beyond the ordinary draughtsman's duties and is not found wanting, and for these services he is generally looked upon by the employer as a necessary evil. He may, if lucky, after years of useful work, obtain a salary of 70*s.* or 80*s.* per week, although his cost to his employers in salary is about 1 per cent. of the cost price of the article produced.

This letter may also serve as an answer to the chairman of Messrs. Cammell, Laird and Co., Limited (Mr. Hichens), who, in a recent speech, deplored the fact that so few public school men joined the engineering profession. That the draughtsman himself was to blame for this state of affairs until quite recently is not disputed, owing to the fact that he was not combined, like all professions are, and should be, for their own protection. Happily, this state of affairs is now corrected, and all draughtsmen who are not already members should immediately join the Association of Engineering and Shipbuilding Draughtsmen, with headquarters in Glasgow and branches throughout the British Isles and abroad.

Yours faithfully,
February 8, 1917. "MERSEYSIDE."

To the Editor of Engineering.

SIR,—Why does your leader of the 2nd instant stop at the remuneration of toolmakers and draughtsmen? What of the managers of the larger limited companies, and the directors of private companies (who are generally the owners also, and whose remuneration, in the words of the Inland Revenue Authorities, "partakes of the nature of a distribution of chargeable profit"), and in particular, what of the partners in firms engaged in the engineering trade under the control of the Ministry of Munitions?

Semi-skilled workers on repetition work are drawing relatively very high rates of remuneration. The toolmakers and draughtsmen you mention have all had some advances, but the higher up the scale of responsibility and the less is the financial consideration shown by the Government. Managers have had limited advances allowed on their salaries, the claims of directors are still under consideration, but partners are to have nothing at all! The increased cost of living has affected these just as much as others.

The whole question is a much more serious one for the future of the British engineering trade than seems to be generally realised. The depletion of the financial resources of engineering concerns, due to the combined effects of "Excess profits tax," increased income tax, and reduced opportunities for proper renewals and repairs, can only result, at the present rate, in the owners being left with obsolete scrapheaps where formerly they had properly equipped workshops, and without any cash reserve to replace the worn-out machinery when the period of control ceases, and when the country will look to the engineering trade to help it to hold its own in foreign business.

The engineering trade has saved the situation by supplying in a great emergency the necessary materials for war, and is at the same time chosen as the one industry to be restricted in profits. At least all trades might be treated alike.

I remain, yours truly,
DANIEL ADAMSON.
Longlands, Hyde, February 8, 1917.

* The actual cylindrical section was not in time for publication in the paper, but was exhibited at the meeting; a photograph will figure in the final report of the discussion.

SCREW GAUGES.

To the Editor of Engineering.

SIR,—The method of correcting the progressive error of the lead screw of a lathe by suitably chosen change wheels, which was mentioned in the paper on gauges recently read at the Institution of Mechanical Engineers and referred to in Mr. Sears's letter this week, is not new, though, of course, I am unaware whether it was worked out independently by the authors of the paper.

I have seen references to it in the *American Machinist* about 10 years ago as being used to cut taps slightly long in pitch to allow for contraction in hardening.

The difficulty in using the method appears to be that some of the wheels are not usually found in sets of change wheels provided with a lathe, and also that arrangements for dividing the special wheels which may be required are not common, and unless the spacing is very accurately done a periodic error will be introduced.

My experience in cutting some test screws, which were kindly measured for me at the National Physical Laboratory, has shown me that the change wheels may be the cause of a very erratic periodic error.

Yours truly,
W. H. NEWMAN.
Totteridge, Herts, February 10, 1917.

ELECTRON, QUANTA AND RELATIVITY THEORIES.

To the Editor of Engineering.

SIR,—"Sesamy" appears to be under the impression that my letters are confined to replies to his very indefinite questions. I am indebted to him for keeping the discussion alive, but he does not seem prepared to discuss the subject-matter of the title. He asks for the temperature of a ray of heat without specifying the particular ray.

So soon as I can collect the particulars I hope to draw a diagram giving "definition without penumbral haze" of the energy-quanta of X-rays which should indicate that Moseley's atomic numbers are intermediate factors of action-quanta and of atomic weight; but, meanwhile, I beg to withdraw from the discussion.

Physicists to-day dare not discuss action-quanta in place of energy-quanta because the immediate corollary is an atomic ether in place of Tyndall's "vibrating multiple-proportion," and in this connection I cannot refrain from again quoting Maxwell, whose clear physical ideas are in strange contrast to the misty profundity of the several schools under discussion, each of which tries to deny the conclusions of the other. "Treatise," vol. ii, articles 865 and 866, page 448:—"There appears to be in the minds of these eminent men some prejudice or *a priori* objection against the hypothesis of a medium," &c.

Yours truly,
FRED. G. EDWARDS,
33, St. Ronan's-road, Sheffield, February 10, 1917.

KAPOK FIBRE.—According to Messrs. C. F. Cross and F. J. Bevan, Journal of the Society of Dyers, volume 32, pages 274–278, true kapok is the seed hair of *Eriodendron anfractuosum*, though other vegetable downs pass commercially as kapok. The chief use of the material is for stuffing lifebelts, etc.; the fibre keeps out of the water, not because it contains much water-repelling oil or resins (these are found up to 1.8 per cent.), but because the fibres form thin-walled tubes filled with air. The fibres are remarkably uniform as regards diameter (0.021 to 0.028 mm.). The air is not expelled by immersion of the fibre in hydrocarbons. Sinking tests of kapok in water take very long times; in aqueous alcohol of density 0.928 tests as to grade can be carried out more expeditiously. In life-saving appliances one gramme of kapok occupies about 15 cub. cm., and a jacket containing 700 grammes of this stuffing would have a floating power of 10.5 kg. After having been suspended in water for 72 hours with a weight of 9 kg. attached the jacket still required 1.3 kg. more to submerge it, and after 192 hours 0.9 kg. were required to sink the jacket. We have referred to kapok tests carried on in the National Physical Laboratory before the war.

THE ALUMINIUM RESOURCES OF THE CENTRAL POWERS.

Aluminium can only be produced on commercial lines by the prodigious expenditure of power turned into electrical energy, and such power is only available at a low figure by harnessing the natural resources of water-power. As far as we are aware there were but two aluminium works in existence in the territory of the Central Powers before the war, one in Austria and one in Germany. The principal supplies of bauxite before the war came from the south of France, from where most of the European aluminium works, including our own, drew their supplies; we, however, augment our supplies from Larne, in Ireland.

Germany, as well as Austria, has, it is true, indigenous bauxite resources which were exploited formerly, but were obviously abandoned on account of their inferiority to those of France; but now they are once more dependent upon their own resources, to which they have vigorously resorted again.

The principal German bauxite supply is drawn from the Vogelsberg, a small range of mountains, and the most important working is known as the "Hessen," exploited by a firm at Honau. The bauxite of this range is the product of decomposition of basalt rock.

The Austrian bauxite is found pretty generally distributed over the Eastern Alps, where "Wocheinit" is principally worked, in the neighbourhood of Laibach. "Wocheinit" is a lower grade of a clayey bauxite which reaches a thickness of several yards in the neighbourhood of the Wochein Lake. The Austrian aluminium works are at Lent-Gastein, in Styria, and those on German territory at Rheinfelden, near Basle.

As to the annual capacity of these two works, if we base our calculations on pre-war conditions, the available water-power in the two establishments is approximately 30,000 h.p. together, and if the whole of this is now devoted to the production of aluminium —which it was not before the war—the maximum output of the two works would be about 5,000 tons per annum.

Swedish Electricity to Norway.—Electric energy seems destined to become a negotiable international commodity. The transmission of Swedish electric current underneath the waters of the Sound works admirably, and now another scheme is being prepared. The city of Drontheim is in need of more energy, and besides the regulation of the Selbu lake, which is pending, another scheme is being proceeded with in connection with the damming of the Nea valley in Sweden. The land in question is owned by some Laplanders, who are willing to part with their property, and the project is being prepared. The municipality of Drontheim will have to apply to the Swedish Government for the necessary concession, but no difficulties are anticipated in that connection. The capacity of the contemplated hydro-electric station is calculated at about 6,000 h.p. The height of the fall after regulation will amount to some 30 m. (98 ft.).

Galalith.—The substance galalith, which came on the market some time before the war, is a German-made insulating material which resembles horn and celluloid, and consists essentially of casein and formaldehyde. The chief manufacturers are the Internationale Galalith Gesellschaft of Hamburg. According to the United States Commerce Report of last October, compiled by Mr. H. H. Morgan, galalith is prepared by heating skimmed milk with caustic alkali; from the clarified solution the casein is precipitated by means of acid and filtered. The water is removed by compression and by drying; the latter process has to be very slow and takes several weeks. The resulting dry casein plates are saturated with formaldehyde and dried again. The final product is of a yellow-white colour and translucent and makes an excellent insulator, which may be shaped cold after having been softened by the aid of hot water. It has no odour and is less inflammable than celluloid; but it is not quite transparent and cannot be prepared in the thin films in which celluloid is utilised. The specific gravity is about 1.32, the hardness 2.5 on the Mohr scale.

Scarcity of Iron.—Both in Norway and Denmark there is great scarcity of iron, the manufacturing engineers are, in many cases, very awkwardly placed, and Germany seems determined to uphold her recent restrictions and increase in prices. In Denmark a kind of official iron central board was formed in the autumn for the distribution to Danish customers of the iron which could be obtained from Germany. This central board has now been in operation for a couple of months, but so far no results have materialised, the agreements entered upon by Germany not having been carried out by the latter. German manufacturers state that Danish orders accepted months ago at the prices fixed by Germany, and to be paid for in kronen instead of marks on account of the wretched exchange for the latter, will not now be executed unless the Danish buyers agree to pay 60 or even 70 per cent. more than the price at which the goods were actually bought, and the original prices at which such goods were bought in August, 1916, were about three times as high as the prices ruling in 1914. The German vendors simply cancel the orders duly accepted by them, and make their own arbitrary and unjust terms a *sine qua non* condition for delivery.

THE LATE MR. FREDERIC WILLIAM MARCHANT.

We regret to have to record the death, which occurred on the 11th inst., at 22, Cholmeley Park, Highgate, of Mr. Frederic William Marchant, M.Inst.C.E., of Timaru, New Zealand. Mr. Marchant was born on April 27th, 1852, and was educated at King's College, London, for the profession of mechanical engineer. He was articled from April, 1869, to June, 1873, to Mr. William Smith, mechanical engineer, Cavendish Engineering Works, 57, Wells Street, London. He was later, from February, 1874, to February, 1878, cadet in the New Zealand Public Works Department, under Mr. John Carruthers, and subsequently was employed on various railway works in New Zealand—at Waitara, New Plymouth Railway; Dunedin, Invercargill Railway; and Amberley, Waitaki Railway. Mr. Marchant then held the position of assistant engineer in the New Zealand Public Works Department for one year, and was appointed engineer to the Mount Cook Road District in January, 1879, a position which he held for several years. He executed important bridge, road and water-supply works for the counties of Mackenzie, Geraldine and Waimate, in Canterbury, New Zealand, where he had the exclusive charge of such works. In the middle 'eighties of last century he was appointed engineer to the Timaru Harbour Board, where he had the sole charge, among other work, of the design and construction of the Timaru breakwater. Mr. Marchant also directed the construction of several works of harbour equipment and improvement. In the course of his engineering activity in New Zealand he designed and constructed wharves, slipways, and breakwater extensions; he also designed dredgers and superintended their operations. Mr. Marchant was appointed an associate member of the Institution of Civil Engineers in December, 1881, and became a full member in November, 1892. In December, 1884, he read before the Institution a paper on "The Tekapo Bridge, Mackenzie County, New Zealand," a bridge which he designed, of three spans, the centre one of 150 ft. and the end ones of 75 ft. each, to carry the traffic of the inland road between the provinces of Canterbury and Otago over the Tekapo river. The bridge replaced a ferry which had frequently to lie idle by reason of floods and heavy north-western winds.

THE OPTICAL SOCIETY.

The annual meeting of the Optical Society was held on February 8 at Burlington House. After the report of the council and accounts for the year 1916 had been adopted it was announced that the following had been elected for the year 1917–18:—President, Mr. F. J. Cheshire, F.R.M.S.; Hon. Treasurer, Mr. H. F. Purser; Hon. Secretary, Mr. Wm. Shackleton, F.R.A.S.; Hon. Librarian, Mr. J. H. Sutcliffe; new Members of Council, Mr. L. C. Martin, B.A., Dr. Walter Rosenhain, F.R.S., Mr. T. Smith, B.A., Mr. F. Twyman, Dr. R. Mullineux Walmsley, F.R.S.E., Mr. R. S. Whipple, M.A., and Lieut.-Colonel A. C. Williams, R.E. A vote of thanks to the officers and council for their services during the past year concluded the proceedings.

An ordinary meeting followed, at which the following were elected members of the society:—Mr. W. Anderson, Mr. J. E. Barnard, Mr. G. A. Carse, D.Sc., Mr. Charles Cochrane, B.Sc., Mr. A. V. de Braun, Mr. G. A. Richmond, Mr. A. R. Robson, and Mr. Victor Towns.

A paper by Mr. James Weir French, B.Sc., was read, entitled "More Notes on Glass Grinding and Polishing." The paper may be regarded as a continuation of an earlier one delivered to the society in November, 1916, which dealt particularly with the surface layer of polished glass. In the introduction the principal conclusions of the first paper were briefly enumerated. Sections of the paper were devoted to questions of abrasion, polishing, the cracking of the polished layer under special circumstances, and the explanation of various phenomena arising from the surface cracking. Glass is abraded by splintering, and the efficiency of an abrasive is determined by the form of the grains, their general hardness, and particularly their cleavage. A grain that cleaves and presents flat surfaces loses its cut, whereas one that retains its original good form when broken down suffers only a temporary loss of cut during the grinding process.

Microphotographs of carborundum, emery and Fontainebleau sand in their fresh and worn conditions were exhibited as typical illustrations. When precautions are taken to prevent clogging of the abrasive, the amount of glass removed was shown to be directly proportional to the relative speed of the grinding tool and the glass. Lubrication is a question of importance. Too much water had the same bad effect as too little water, for reasons that were discussed. Abrasive wheels act generally in the same manner as loose abrasive. It is not safe to judge glass by analogy with metals. A new method was described of comparing and recording the qualities of ground glass surfaces, and results for typical surfaces were given.

Polishing was divided into two stages: wet polishing, in which material is principally removed; and dry polishing, in which the surface sleeks are filled or closed. There is also some slight removal of material during the second stage. The removal of material under various conditions was illustrated by the results of tests, in some of which no polishing medium was employed. From experimental evidence a general mechanical theory of polishing was elaborated.

Microphotographs were exhibited of the material removed during polishing in comparison with the grains of the polishing medium. Rouge consists of grains of ultra-microscopic size. These grains, however, appear to gather, snowball fashion, into lumps of about two wave-lengths diameter, and in this condition they plough grooves or sleeks in the surface layer. During the second stage these sleeks are closed up, thus improving the brilliancy of the surface.

When a steel ball is pressed on polished glass a concentric crack is produced in the surface layer. This crack may later extend to the underlying material. When a rounded point is drawn heavily over the surface, a series of semicircular cracks is produced. It was shown that the cracking takes place on the tension side and not on the pressure side, thus demonstrating that the cohesion of the surface layer is considerably less than that of the underlying material. The diameters of the cracks produced have a very definite relationship to the pressure on the ball. With the semicircular cracks there are associated two series of tangential cracks, one set corresponding with the 45 deg. line of maximum shear, and the other being inclined to the axis at an angle of from 5 deg. to 7 deg. Fire-glazed surfaces and fracture-glazed surfaces give similar results, indicating the existence of a definite surface layer. Polished quartz also gives similar results, but the natural polished surfaces of crystals resulting from crystal growth and not from the mechanical or thermal agitation of the surface molecules do not exhibit either sleeks or surface cracks, thus suggesting the non-existence of a surface layer.

In conclusion, the permanent marking of glass by French chalk and certain other materials was explained as being due to the cracking of the surface layer. Other subjects were also discussed, such as the cracking of glass by scratching and by the drying of gums and glues, the chemical theory of polishing, and the welding of polished surfaces.

In the discussion which followed Mr. S. D. Chalmers, Mr. C. B. Ustouston, Dr. Walter Rosenhain, Mr. A. E. Conrady, Dr. R. S. Clay, Mr. P. F. Everitt, Mr. W. Shackleton, Mr. H. R. Fairbanks, Mr. W. Anderson, Mr. G. S. Dey and the president took part. A vote of thanks was accorded the author.

The Commercial Motor Users' Association and London Hospitals.—The General Committee of the Commercial Motor Users' Association has placed the sum of 100*l.* per annum at the disposal of its chairman, Colonel R. E. Crompton, C.B., and its hon. treasurer, Mr. E. S. Shrapnell-Smith, for allocation, in five sums of 20*l.* each, to the general funds of five London hospitals.

Women Drivers of Motor Vans.—The first entry from a woman driver in connection with the annual drivers examinations conducted by the Commercial Motor Users' Association since 1907, with the object of encouraging drivers of commercial motor vehicles to take a personal interest in their vehicles, has been received from a lady in the employ of a well-known London house. It is hoped that this example will be followed. Cash prizes to the value of 150*l.* are being offered. Full particulars and entry forms may be obtained from Mr. Frederick G. Bristow, F.C.I.S. (secretary), the Commercial Motor Users' Association, 83, Pall Mall, London, S.W.

The "Practical Engineer" Pocket-Books and Diary.—The Technical Publishing Company, Limited, 1, Gough-square, Fleet-street, E.C., have sent us a copy of their "Practical Engineer" Mechanical Pocket-Book and Diary for 1917. It opens with advertisements and a buyer's guide in English, French, Spanish and Russian, then follow over 600 pages of useful information: units of measure, arithmetic and other data, particulars on steam, steam boilers, engines, engine parts, lubrication, steam turbines, pumps, internal combustion engines, machine-tool work, bearings, power transmission, &c. The diary portion, one week per page, is at the end of the book. This gives also French, Spanish and Russian vocabularies. The price is 1*s.* net bound in cloth, and 1*s.* 6*d.* net in best binding. The same publishers issue at the same prices the "Practical Engineers'" Electrical Pocket-Book and Diary for 1917. It is got up on the same principle and covers all classes of electrical work. Both books are clearly printed and will be found useful for reference purposes.

Paraffin Paper Waste.—The recovery of the paper fibre and the paraffin contained in old paraffin paper which is soiled with ink would appear to be fairly easy according to experiments made by Mr. W. H. Smith, of the United States Bureau of Standards (Technologic Paper No. 87). The waste is pulped in a vertical boiler which is fed with exhaust steam. The paraffin rises to the surface and is drawn off together with the water, from which it is separated by the aid of a screen; the fibre pulp or stock settles at the bottom. The stock is transferred to a beating engine and treated there with hot water, soap, and turkey-red oil, or with caustic soda and water; the oil is added to facilitate coalescence of the fine paraffin particles still retained by the stock; the amount of caustic soda increases with the amount of ink in the paper. The paraffin freezes on a cylinder which is suspended in the upper part of the vessel and kept cold internally by water, and the stock is returned to the paper mill. Almost all the cellulose is said to be recovered in this way, whilst 10 per cent. of the paraffin will probably be lost.

SCREW THREAD MEASUREMENT.*

By ARTHUR BROOKER.

(Concluded from page 141.)

(4) MEASUREMENT OF PITCH BY MECHANICAL MEANS.

OPTICAL methods cannot at present be applied to the measurement of female screw threads. The staff of the National Physical Laboratory have recently designed an improved mechanical pitch-measuring machine, using a beam of light as an auxiliary, and this machine promises to become of great value, as it is not only free from the personal error of the observer, but it affords a means of directly measuring the pitch of a female as well as a male screw thread with great accuracy.

The instrument is shown in Figs. 25 and 26. A bracket, on which is mounted the male or female screw under measurement, can be traversed on bearing slides by a micrometer head in the direction of the axis of the screw. This micrometer head indicates the exact distance

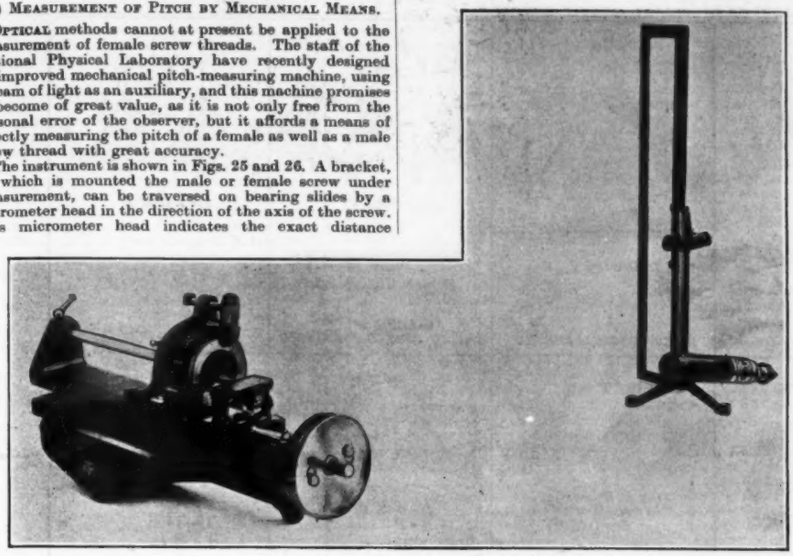


FIG. 25.

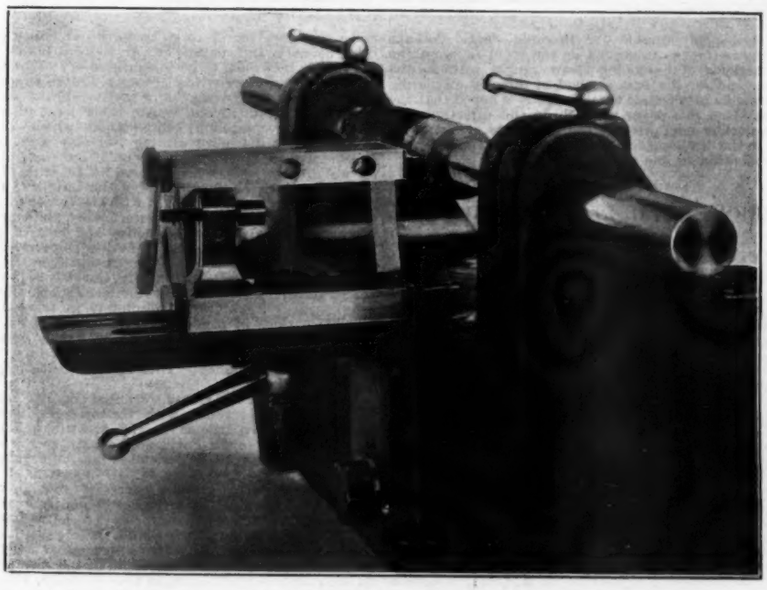
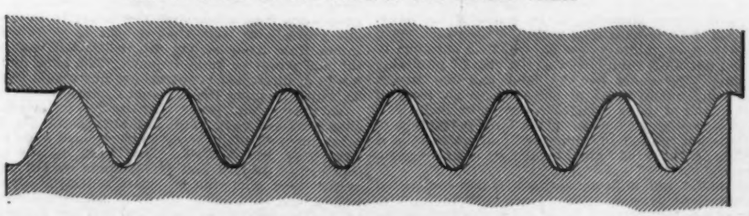


FIG. 26.

Fig. 27. PITCH ERROR BETWEEN MALE AND FEMALE SCREWS - SHOWS HOW THE LOAD IS TAKEN ON THE SLOPE OF ONE THREAD ONLY.



traversed when the screw moves through the space occupied by one or more screw threads, and a novel and essential part of the apparatus is the means for determining precisely when similar points on the different threads reach a given fixed point. A stylus or tracing arm, with a rounded point, is mounted at centre height; it has motion only at right angles to the screw's axis, under the control of two wide flat steel springs. The stylus bears in the groove between threads of the screw to be measured, so that the small rounded end touches neighbouring slopes. The point of contact in the slope is not important, provided that it is clear of the curvature at root and crest. When the bracket carrying the screw is traversed by turning the micrometer head, the stylus moves outwards from the screw, riding up the slope of the thread, over the crest and down again into the neighbouring thread. Fig. 26 shows an intermediate position of the stylus in its transit; this illustration also indicates the method of mounting the stylus in the edge of the moving platform, and the manner of its parallel motion under the control of the two flat springs.

With the stylus in its nearest position to the screw's axis, it makes contact with equal pressure upon each slope; the slightest side pressure exerted by the screw on the stylus has the result of causing the latter to travel up one slope of the thread.

Attached to the platform (see Fig. 26) and at the opposite end to the stylus is a light flat spring which carries a small mirror at its lower end. This spring is made to take up a sloping position by the adjusting screw shown, and thus any horizontal movement of the platform carrying the stylus results in a change in the inclination of the mirror spring. A small beam of light is projected on to the mirror from a suitable source, such as a galvanometer telescope, and reflected back to a vertical scale. The light spot will rest at its highest point on the scale when the stylus is in the mean position between threads, as described above. This position may differ with each new screw inserted for measurement when the stylus platform has been adjusted to the screw.

In operating the machine the micrometer head is screwed up and results in the screw travelling horizontally past the stylus point, which remains in constant contact with the thread profile in an axial plane, by reason of its horizontal motion, at right angles to the screw's axis. Micrometer readings are taken each time the light spot reaches its highest point on the scale.

As micrometer heads are not yet available in sizes greater than 1 in., distance pieces are inserted between the micrometer spindle and the sliding bracket carrying the screw when a greater travel than 1 in. is required. The distance pieces are finished by a Hoffman ball spun into one end so that less than a hemisphere projects. By this means pressure is transmitted to the moving bracket through the point contact between the ball and the plane surface afforded by the end of the micrometer spindle. A similar arrangement is made for the transmission of pressure at the other end of the distance piece, but in this case the ball is mounted in the abutment, and the plane face is afforded by the distance piece. The length of each distance piece is not important, provided that it is accurately determined and periodically checked; the approximate dimensions of the pieces in a set progress by 1-in. steps.

In order to facilitate the pitch readings, removable discs are fitted to the sleeve of the micrometer, as in the case of the microscope machine. These discs are suitably engraved on the periphery, so that for a given screw to be measured the exact number of revolutions and fractions of a revolution can be given to the micrometer head to ensure a movement of the bracket carrying the screw corresponding to the true pitch of the thread. In operating the machine, error in the pitch of each consecutive thread is determined by reading off against a non-rotary disc scale the amount of revolution of the micrometer required to bring the light spot back to zero, short or in excess of the true amount. This fraction of a revolution is read directly off the fixed scale in the form of ten-thousandths and is the positive or negative pitch error. Direct and consecutive readings of the travel of the bracket can of course be taken if desired, but the above method gives the pitch error—as distinguished from the pitch—direct from the machine, and this quantity is the more useful one when plotting results graphically.

Treatment of pitch error by graphs reveals much more information than the scrutiny of a list of figures. Given careful workmanship, pitch errors in screwed work are fundamentally due to pitch error in the originating lathe lead screw, except in the case of taps and dies, where distortion due to hardening comes into account. The error introduced into work by the lead screw may be due either to inherent pitch error in its thread or to the influence of the bearings and abutments of the lead screw upon its rotation. In correcting lead screws it is obviously of supreme importance to know which class of fault has to be dealt with, and a study of the graph of a screw's pitch errors will indicate the very class of pitch fault in the originating lead screw.

One of the effects of pitch error is shown in Fig. 27, from which it can be seen that under certain conditions the whole load is taken on one slope of one thread. This is a common cause of stripping or shearing; the first thread shears, and the load is passed on to each thread in succession until all are sheared.

SECTION IV.—CONCLUDING REMARKS.

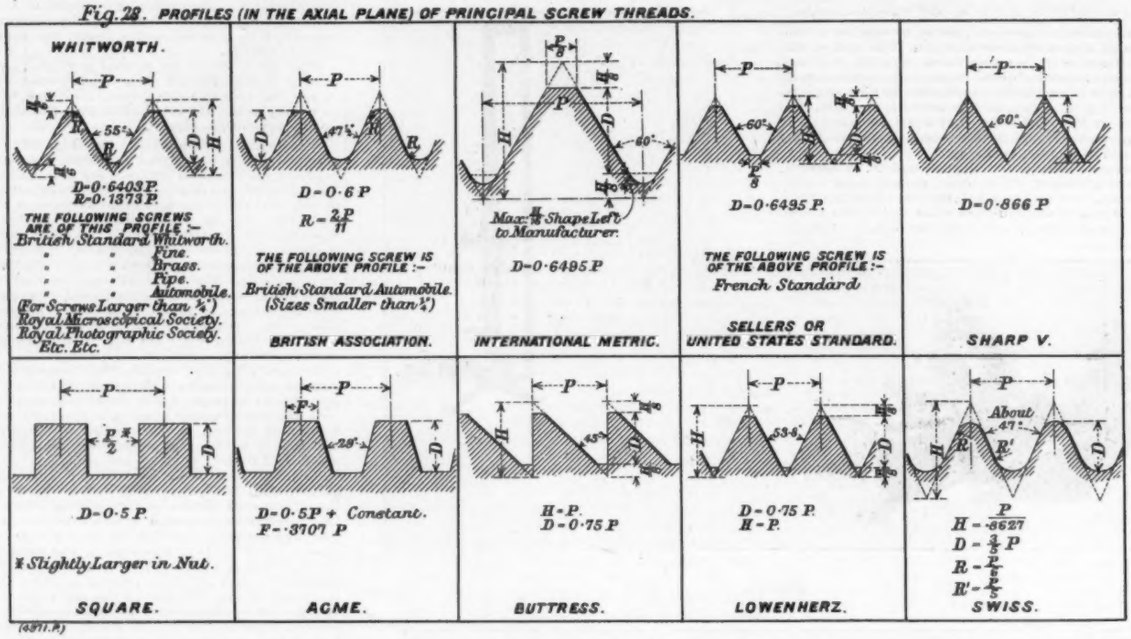
It may be asked, "Is it ever really necessary on screw threads to be able to measure and work to a ten-thousandth of an inch or less, or to a quarter of a degree of angle or less?" The reply is, "Yes," and, moreover, it has been proved on a large scale that such ability is one of the best means of saving money, and therefore of increasing profits when manufacturing in large quantities. Such limits are only occasionally demanded on the actual work, but they are necessary for master gauges, and the measuring apparatus cannot be too well made nor its use too closely studied. The publications of the National Physical Laboratory give good information respecting gauges, gauging and limits for gauges. Figs. 18, 19 and 20, page 140 *ante*, of this paper deal with three possible sources of error in measurement in cases where it is desired to measure to less than half a mil.

It should be remembered that a marked improvement

* Paper read before the Liverpool Engineering Society. In our issue of last week, page 139 *ante*, in the first column, Figs. 25 and 26 were referred to in connection with measuring the core diameter. These references were given in error for Figs. 15 and 16, which occurred on the same page. Figs. 25 and 26 appear in the present issue.

SCREW THREAD MEASUREMENT.

Fig. 28. PROFILES (IN THE AXIAL PLANE) OF PRINCIPAL SCREW THREADS.



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in the quality of the whole of the work in any factory can be observed when any section of it attains the high standard needed for the production and checking of master gauges or similar work. Were this country in a position to produce the whole of the measuring apparatus required in its workshops, the experienced skilled workmen and good machines which would be called into existence and supported would be of the utmost value in many other directions.

Highly efficient measuring apparatus, such as that herein described, is too often used solely for the purpose of discovering when work has not been sufficiently well done; it would be better if more of such apparatus were used during the actual production of work, thus assisting the workman in avoiding errors.

The term "mil" for one-thousandth of an inch was introduced by telegraph engineers, and has been adopted by the Engineering Standards Committee. A convenient and distinctive term for one ten-thousandth of an inch would be useful in the workshop.

Those in favour of adopting the metric system of measurement might find good arguments in connection with screw threads. Millimetres and fractions of an inch can with some labour be made sufficiently interchangeable, but not so the screw threads based on them, and many difficulties would be surmounted and much labour saved by going over boldly to the metric system, especially for those people who endeavour to supply foreign markets. The usual compromise, however, is useless.

The value for small screws of the excellent British Association thread, based on the Swiss metric thread, was greatly reduced by the decision to convert the simple figures on which the thread is based to awkward fractions of an inch having no evident interconnection, and to work on those fractions.

Commercially produced screws differ, on the average, so much from the standard that a moderate departure from the theoretically best figures in fixing a standard thread would cause no actual loss in efficiency, but would even result in the production of more efficient screws if the amended standard were easier of production.

The author believes that in deciding on a standard form of thread for interchangeable screws required in large quantities, the screw itself should receive only secondary consideration, and the object should be to design a thread of such a form that tools, taps, dies and gauges, particularly hardened gauges, could be readily made and have the maximum life, because tools and gauges, after a certain point, are almost the sole factors in determining output. It is easier, for example, to make tools to an angle of 60 deg. than 55 deg., because the former is a natural angle. In most workshops the formation of the correct crest and root on a Whitworth thread is found to be a most difficult operation, and great irritation is caused because these elements are recognised as of secondary importance, although under existing conditions they cannot be treated as such.

At some later date we shall, for screws required in large quantities, probably change to a thread based on metric measurements, with an angle of 60 deg., a simple form of crest and root, and a moderate amount of clearance between these elements, but the author hopes that when any such change is contemplated the casting vote will be given to the producer of dies, taps, chasers and hardened gauges.

In the meantime screw gauges are generally used soft, with consequent trouble due to rapid wear. Perhaps the information most needed at the moment is on the best methods of hardening screw gauges without distortion, and on the best method of directly measuring the elements of a female thread, and it is hoped that the discussion on this paper will help in this direction.

The author acknowledges the assistance of Mr. P. T. Bates in the development of the apparatus described, and its application to fine measurements.

AMERICAN NAVAL STATIONS AND NAVAL BASES.*

By Captain A. P. Niblack, United States Navy, Vice-President.

It is important that this country awaken to its strategical requirements in the Atlantic, Pacific and Caribbean, and, as the principles governing the selection and outfitting of naval stations and naval bases are not generally recognised, it is the intention here, as briefly as possible, to touch on the elements of the problems awaiting us. The type of statesmanship which attains its highest ambition in securing a naval station as a local improvement at national expense, and that type of citizenship which secretly hopes that there is some cheap, honourable and unannoying way of saving the nation at reduced rates, will derive cold comfort from the actual facts. There are special considerations, in the case of this country which require clear recognition :—(1) We are the only country facing equally on two great oceans with full responsibilities on each. (2) We are, in our relations with other Powers, practically an island, with widely outlying colonial possessions in the Atlantic, Pacific and Caribbean. (3) We are committed to the policy of forming no alliances, and must go it alone. (4) We are the sole remaining country not to adopt the principle of universal military service as being synonymous with the great democratic principles of equality before the law, equality of opportunity, and equality of responsibility. (5) We are the sole remaining country in the world in which the coast defence is not entirely, or almost entirely, in the hands of the navy. (6) We are the sole remaining victim in the whole world of the voluntary military system, which is enormously expensive per unit, prohibitive in the cost of providing "adequate" *personnel* for the land and sea forces, and foolishly extravagant in pensions, in the cost of recruiting, and in the inducements, pay and "bounties" which it is necessary to offer. (7) A large percentage of our population consists of undigested and unassimilated foreigners, of whose individual loyalty we must entertain serious doubts.

When naval and military authorities are confronted with the task of drawing up war plans in time of peace, they must ask themselves a lot of questions such as the following :—What is the best thing to do, not with what we ought to have, but with what we actually have and can expect to have? Is our particular policy which threatens trouble in a given locality, or with a given nation, vital to us, and does it threaten a vital interest of the other nation? Would a war in support of such policy involve us with other countries? How far will it be necessary for us to go to force our policy on the other country, and, in case of war, to what limits would our people be willing to go to continue it? Would both nations throw their entire strength and resources into a fight to the death—that is to say, would the war be a limited or unlimited one? Are there local (domestic) or foreign (international) complications which will force us to adopt a defensive strategy, or may we count on an offensive, or what would ever be in our case, situated as we are, an offensive-defensive? In case of war, shall we attack at once or leave the initiative to the enemy? May we plan to fight with the nation as a unit behind us, or may we expect interference and confusion from local politics, or indifference and lack of public sentiment to sustain the war? Let us, however, assume that wise statesmanship, patriotic sentiment and national spirit are back of us. Fortunately, in times of profound peace, naval strategy, in the unobjectionable form of peace strategy, enables us absolutely to forestall the possible actions of other countries in any given area, and, while enforcing our own policy, may make resistance or war inadvisable on the part of another country which may oppose such policy. Thus has the British Empire been consolidated.

We recently, by treaty, secured control of the Nicaraguan Canal route, with the necessary terminal bases at the Corn Islands in the Atlantic, and in the Gulf of Fonseca in the Pacific. We have, in our actual possession in the West Indies and in the Pacific, absolute treasure islands of strategy for the location of those advance and outlying bases necessary to supplement the fleet we are building, which will jointly guarantee us that measure of command of the sea as will give us the national security which we all crave and which, at this moment, to our peril, we actually lack. It is merely a question of intelligently willing to do it, and then putting up the money. In doing it, in time of peace, we offend no innocent country, but we might bring on a war by undertaking even a small part of it during a time of strained relations. No one waits until it rains to begin repairing the roof.

To establish ourselves securely within the political areas in which our manifest destiny lies not only removes temptation from other countries to try to overreach us, but protects us from that danger to ourselves which comes from using strong diplomatic language without the real power to make it good. The siren and lulling words of interested countries are not a safe foundation on which to build the national defence.

To outline our peace strategy let us assume that, among all our navy yards and stations on the Atlantic coast, our two main bases to be decided upon are, say, New York and Norfolk. New York, as the assumed centre, and Boston and Philadelphia on the periphery of the circle enclosing the main industrial area of the United States, become the true strategical centre the instant we deepen the Cape Cod and the Delaware and Raritan canals into ship canals, clear the East River of all obstructions from the Battery to Long Island Sound, and adequately fortify Block Island, Vineyard Sound, Buzzards Bay and Cape Cod Bay regions. With exits at Delaware Bay, Sandy Hook, Block Island and Massachusetts Bay the entire British navy, as it exists to-day, could not contain our own navy as it is, although it is continually able to contain a much larger and more powerful one, the German navy, even with the two exits it has by virtue of the superb Kiel Canal.

* Paper read at the 24th general meeting of the Society of Naval Architects and Marine Engineers.

Our "Heligoland," Block Island, is now only a summer resort, but, defended as it should be, it would be the armed sentinel at the gate. The region around New York of which we speak represents billions of dollars, and the expense of providing mobility to our naval forces and security to the area would be but a fraction of one per cent. As a mere commercial proposition the enlarged waterway would pay without the guns and mines to secure it, in case of war, and the present serious trend of public opinion makes the whole question one of easy possibilities. The defences of Cape Cod Bay, Narragansett Bay, New York Bay and Delaware Bay are one and the same question, and the area from Boston to the Delaware breakwater is our main strategical area.

Our second considerable strategical area is that of Chesapeake Bay, embracing Washington and Norfolk—that is, the national capital and an immensely important naval base. It is far along in our plans to speak of the very desirable proposition of the Delaware and Chesapeake Canal as a ship canal, but it is easy enough to see what it would add to the mobility of our naval forces and to the security of our coasting trade in case of war. Just now the adequate defence of Chesapeake Bay entrance is the main consideration, for we have left that "stable door" wide open, as we have also the Delaware Bay entrance. It is therefore idle to talk too much theory when our practice is so elementarily careless.

The first commanding strategical point in connection with the Panama Canal and its approaches is Key West. Mahan, in his "Naval Strategy" (page 317), says, "There is nothing that can be said about the interests of the United States in the Panama Canal, as connecting the Atlantic and Pacific coasts, that does not apply with equal force to the Straits of Florida as uniting the Atlantic to the Gulf of Mexico and the Mississippi Valley." Its main importance is in its relation to Cuba, whose political integrity we are pledged to defend. Cuba is, in effect, as far as Guantanamo is concerned, the absolutely undefended mainland of the United States, since it is up to us to defend it from invasion—and we have taken no steps thus far to do so.

In considering the defence of the approaches to the isthmian canal route in the Atlantic and Caribbean, the most striking fact is the commanding position of Great Britain, with Bermuda less than 700 miles from Cape Cod, Sandy Hook, and Cape Henry, and with the Bahamas, Jamaica, St. Lucia, Barbados, and Trinidad commanding the approaches to the canal from all directions. While we all habitually assume the benevolence of British policy toward us, it is not a justifiable strategic assumption. One should not leave his business affairs entirely in the hands of anyone else, if it can be avoided. Fortunately, we already possess the necessary positions to secure the approaches to the Caribbean against all comers, and all we need is the sagacity to add to the strategical positions the necessary strength, resources, and mobile defences to make them good. We have the tactical defences of the Panama Canal itself well under way and well understood; and we have Guantanamo, "on the mainland," dominating Jamaica and the Windward Passage; but we have, over and beyond all, Culebra Island, the neutraliser of Bermuda and the British West Indies positions—the ideal outlying strategical base—situated 20 miles east of Porto Rico and 20 miles west of the Danish island of St. Thomas. For the price at which we could possibly purchase the Danish West Indies we could make them useless strategically to anyone else by spending the money on Culebra, only 20 miles distant from St. Thomas.

Almost every drawback that may be glibly cited against Culebra as our great naval base for our fleet in the Atlantic is really an advantage. For instance, it is usually argued that the island and its harbour are too small, whereas, if anything, the island is too large, and the harbour could be even smaller before it would cease to be ideal. Of course it is out of the question to expect to find a ready-made naval base, and we are in luck to have all the treasures we have. There, is above all, no question of Culebra versus Guantanamo, because the latter merely supplements the former. There may be a Culebra without Guantanamo, but no Guantanamo without a Culebra, because Guantanamo is on the undefended mainland, and with Culebra securely held, it would be on the flank of an attacking expeditionary force operating against Guantanamo. As Mahan points out in his "Naval Strategy":—"In short, as to the Caribbean and the Isthmus of Panama, Guantanamo and Culebra can become to the United States what Gibraltar and Malta are to the interests of Great Britain in the Mediterranean and at Suez, with the advantage to us that they are nearer our home ports than those positions are to Great Britain." While statesmen abroad sleep with his books under their pillows, and do not sleep well on that account, the writings of the late Admiral Mahan are not so fully appreciated in our own country.

The Panama Canal defences, although lacking considerably in gun installation, mobile troops and secret-service protection, present the ideal of position, strength and resources, in that it is hardly conceivable that an enemy would be strong enough to operate against them in both oceans at the same time, and we may easily maintain uninterrupted communications by way of either the Atlantic or the Pacific, whichever, at the time, is not under the enemy's control.

On the Pacific coast we recognise the importance of two home bases, one on San Francisco Bay and the other on Puget Sound, and so it remains to consider the question of outlying and advance bases in the strategy of the Pacific. In his splendid book on "Naval Strategy" Mahan says:—"Through the Caribbean Sea lie the approaches to the Isthmus of Panama, the place where the Monroe Doctrine focuses. The Caribbean still remains important, perhaps it has not even quite lost its lead, but it is now balanced by the Pacific . . . National policy now imposes naval stations in the Pacific . . . The selected ports, however, in both oceans obviously can and should form a well-considered system, in which the facilities and endurance of each part shall be proportioned to its relation to the whole."

It will be noted that the positions which Germany held in the Pacific are now held, possibly only for the moment, in other hands, thereby upsetting that balance of positions which gave no one country too great a dominance for our own future good. We have, to be sure, recognised the singular strategic importance of the Hawaiian Islands by half-heartedly providing some of the defences of Oahu Island and Pearl Harbour. Anyone really alive to the actual situation in our Pacific possessions must feel grave misgivings as to our future on that ocean. An ounce of prevention now is worth several tons in the future if our relations became strained, and the remedy lies in intelligent appreciation and conservative but definite action.

Without going too deeply into an analysis of the strategy of the Pacific, there is one thought which we must dismiss from our minds, and that is that we are really ever going to allow anyone to tell us to get out of Guam and the Philippines, or that the moral and economic interests of the world at large will be otherwise than definitely set back by our doing so. To do so voluntarily is enough like the proposition of removing both hands from a sheet of fly-paper to make it difficult to appear graceful in doing so. On the contrary, history will vindicate the acquisition of the Philippines as an act of broad statesmanship, through which we will eventually solve the question of our economic relations with the peoples of the Far East by that exhibition of moral and physical purpose which alone satisfies the oriental mind. Soft words and evasion of issues get you nowhere in diplomacy, and only intrenched position is useful in strategy.

It is an historical fact that no great naval battle has ever been fought in mid-ocean, but always near the bases of one or the other powers, and the ports of supply, or naval bases, indicate the direction of the line which operations must take in time of war and which become lines of communications once the fleet has advanced beyond any one naval base on the route. We already have in the Pacific the heart's desire in strategical positions, and we only seem to lack the knowledge and nerve to strengthen such of them as will permit us to take the initiative and thereby forestall and even prevent war by making it too hopeless for anyone else to take the chances. It is a game of chequers, with our advantage against the whole world as far as mere positions go. It is clearly in our power to compel the strategy of the Pacific in time of peace in such a way as to avoid the possibility of war. Pacifists who preach disarmament as a means of avoiding war are safe enough on the paid lecture circuit, but to be pacific in the Pacific is to be the strong man armed—and there is no other way. That we will ever be so armed in the Pacific no one can believe who recognises the potency of local and political interests in absorbing the substance which might better go to the maintenance of the two arms of national security, viz., a well-paid and well-trained diplomatic corps and a chain of naval bases for our stay-at-home fleet.

Any consideration of the strategy of the Pacific is utterly futile which leaves out the erection of Guam into a great naval base as our key to it for all time—our far-flung outpost of "peace in the Pacific" through armed power in repose. Other positions which we now own, such as Tutuila (Samoa), Dutch Harbour (Unalaska), Sitka, Midway Island, Corregidor, &c., are questions of definite offensive or defensive areas, or of shortening lines of communications, and as such are worthy of consideration as strategic points, but our first necessity is the extension of the defences of the Panama Canal and Pearl Harbour. Then come Culebra and Guam as great insular bases. Meanwhile the other strategical points above enumerated should be treated, for the time being, as possible advance bases; their harbours should be cleared of obstructions, and the necessary equipment prepared accordingly. Even Guantanamo may be, for the time being, regretfully placed in the advance base class.

The problems of our national strategy are so vast and yet so light-heartedly disregarded that it is essential that naval officers and army officers who know the real situation should have with them the instructed understanding and co-operation of all intelligent citizens. Half measures give foreign nations a great advantage when diplomatic relations are strained, because they compel a temporising policy at critical times, for it is then impossible to do anything in the way of hasty preparation, because it will only precipitate war.

We require naval stations and naval bases to correspond with our policies, with our strategy, and with the requirements of our fleet. It means the expenditure of millions of dollars, and is the price of that empire which is ours by destiny, by geography, and by the blood this nation has already shed, but which empire will surely crumble if we sit back. That preparation in time of peace can only be called adequate which leaves only mobilisation as the remaining step in strategy if war unhappily comes. We know what our resources and land and sea forces are, and also those of other nations. We know what our own and other nations' policies are. Our strategy must fit what we have, and if we have little we can do little. The apparent difference of opinion among naval officers as to the needs of the naval establishment, when called upon to enumerate them, is largely merely a difference in the values assigned to the various elements of sea power and the exigencies of the moment, considering how much our strategy lacks in so many directions. At any rate, our military and naval establishments are adequate when they—(*a*) Are superior in *matériel* and *morale* to the corresponding forces of a probable or possible enemy; (*b*) Correspond with the requirements of the Monroe Doctrine and the defence of the Panama Canal; (*c*) Answer the main requirements of our strategy.

As one writer expresses it, "The fundamental condition of success in war is harmony between policy and strategy." Policy may be defined as the attitude or course of action of a nation which influences its relations and intercourse with other states, and as examples we may cite, in our own case, the "Monroe Doctrine," "Asiatic Exclusion," the "Open Door in China," "the Freedom of the Seas," and the defence and control of isthmian canal routes in Central America. Strategy may be defined as the assembling, distributing and directing, in any given area of possible or probable hostile operations, of all the armed strength and resources of a nation to secure best the limited and definite objects of a policy, or war growing out of a conflict of policies. Mahan says, for instance, that the "Monroe Doctrine is only as strong as the United States Navy." That is about true of all of our policies, and it is high time, among other things, that we take up the consideration and study of the question of naval stations and naval bases on the basis of our strategy and the needs of our fleet, rather than on the narrower lines along which such questions are now settled.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several Colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

New Zealand.—H.M. Trade Commissioner in New Zealand writes, under date December 6, that a company has recently been formed in New Zealand, with a capital of 70,000*l.*, with the object of producing iron and steel from magnetic and titaniferous ironsands, of which there is a large deposit on the coast at Taranaki, near New Plymouth, North Island. Works are being erected at New Plymouth, and it is hoped that they will be ready to produce pig-iron in February. The present intention is to instal a furnace capable of dealing with 70 tons of ironsands weekly, but plans have been drawn up for the installation at a later date of an additional furnace, capable of dealing with 200 tons of ironsands weekly. The company claims that, as a result of experiments, and from actual practice, pig-iron can be produced from ironsands at a cost not exceeding 3*l.* a ton. The production of steel is also contemplated, and it is intended later to form a new company to carry out this development. Meanwhile the company will proceed with the production of pig-iron for foundry purposes.

Siam.—With reference to a call for tenders by the Siamese Royal Irrigation Department for the supply and delivery of a suction or hydraulic dredger, H.M. Consul-General at Bangkok has forwarded the name of an American firm to whom the contract has been awarded, together with the price and other particulars of the 16-in. dredger to be supplied. H.M. Consul-General adds that he is informed that the same firm also recently received an order for a 12-in. steam-driven hydraulic dredger, costing approximately 6,800*l.*, which is now being erected at the Royal Irrigation Department's docks. The name of the above-mentioned firm, together with particulars of the contract, may be obtained by United Kingdom firms on application to the Department of Commercial Intelligence. In making application the reference number (78) should be quoted.

Venezuela.—The *Gaceta Oficial*, Caracas, publishes a Decree authorising the construction of a wharf in the port of Ocumare de la Costa and of an aqueduct for the supply of drinking water to that locality. The works will be carried out under the direction of the Venezuelan Ministry of Public Works.

Argentina.—The *Boletin Oficial*, Buenos Ayres, notifies that tenders are invited by the Argentine National Sanitation Department for the construction of an aqueduct bridge of reinforced concrete (or alternatively a steel aqueduct bridge) over Lake Setubal, Province of Santa Fé. Tenders must be made out on the proper forms, and must be accompanied by a certificate from the "Banco de la Nacion Argentina" at Buenos Ayres, or the Santa Fé branch of that bank, to the effect that a deposit equal to 1 per cent. of the official estimate for the work has been made. Offers will be received at the "Directorio de las Obras Sanitarias de la Nacion," Calle Charcas, 1840–60, Buenos Ayres, up to 3 p.m. on February 19. Local representation is necessary. [NOTE.—With reference to the foregoing, it should be borne in mind that the exportation to Argentina of steel bridge-work is prohibited; there may, however, be an opportunity for the supply of material or accessories for bridge construction.]

REDUCTION IN GERMAN RAILWAY TRAFFIC.—At the instance of the German military railway authorities, numerous modifications have recently been introduced in the German railway traffic, with a view of simplifying the working of the lines owing to the military requirements. In the first place the number of trains has been reduced on all lines, and an announcement has been published by the railway department impressing upon the public the necessity of voluntarily reducing their railway travelling, so that compulsory measures may be avoided. The soldiers home on leave from the fronts have also had their railway travelling facilities reduced to a minimum.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

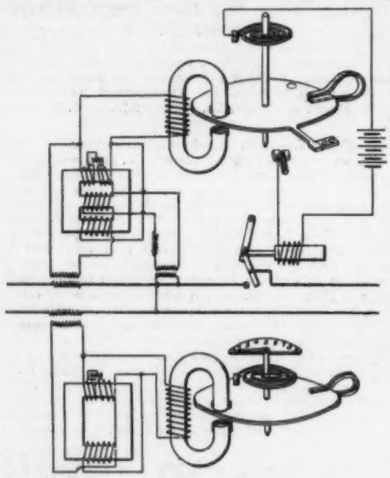
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

ELECTRICAL APPARATUS.

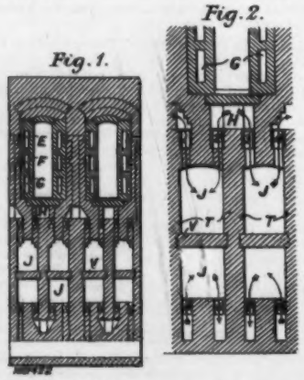
102,335. The British Westinghouse Electric and Manufacturing Company, Limited, Westminster (*Westinghouse Electric and Manufacturing Company, East Pittsburg, U.S.A.*). **Electric Meters.** (1 *Fig.*) June 12, 1916.—An electric meter or relay, according to this invention, comprises a motor having an armature, the torque on which varies as the square of the current in the motor winding and in which the motor winding is connected to the main circuit through a transformer having two windings,



one of which is connected in parallel with the motor winding and the other of which is connected in series with the parallel circuit comprising the motor winding and the transformer winding with which it is in parallel. Further, the transformer interposed between the motor winding and the main circuit is provided with a third winding, which opposes the winding that is in series with the motor winding and receives current proportional to the voltage of the main circuit. (*Accepted December 6, 1916.*)

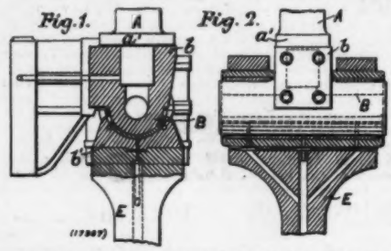
GAS ENGINES, PRODUCERS, HOLDERS, &c.

102,422. J. E. Christopher, Hindley. Coke Ovens. (3 *Figs.*) March 10, 1916. The invention provides a construction of coke ovens in which the two regenerative chambers J beneath each oven are arranged side by side, and are so connected that the air and the heating gases flow through the two chambers in opposite directions, each of the two regenerators being divided into two sections by an horizontal dividing partition V. Combustion takes place in the flues E, F and G, and the waste heat



passes through the sole flue H to the chambers J. The connection of the chambers J with the sole flue H is controlled by dampers 2, 3; with the flues E, F by dampers 1, 4; with the air supply passage R by dampers 5, 7, and with the flue K by dampers 6, 8. Dampers 1, 3, 5 and 7 are closed together and, simultaneously, dampers 2, 4, 6 and 8 are open together. The air flows in the opposite direction to the waste heat and picks up heat thereby, by transference through the division walls T. (*Accepted December 13, 1916.*)

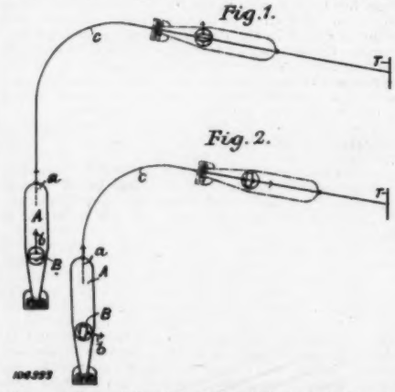
17,307/15. Vickers, Limited, Westminster, and J. McKechnie and J. P. Clear, Barrow-in-Furness. Internal Combustion Engines. (7 *Figs.*) December 9, 1915.—This invention relates to pistons, piston rods and connecting rods intended for use in internal combustion engines of high power. According to this invention, there is bolted upon the end of the piston rod A, or the connecting rod, a separate crosshead or headpiece *b* formed with a cross pin B, which projects at the end of the crosshead or headpiece in an uninterrupted semi- or part-cylindrical surface *b*1, through which is transmitted the thrust due to the working stroke of the piston. As applied to a piston rod A, the piston end of the latter is bolted to the face of the piston, while its outer end is flanged at *a*1 and preferably also stepped to receive the face of the crosshead *b*, which is bolted to the flange. The pin B projects at each side from the crosshead, and the outer



semi-cylindrical half of the pin projects beyond the end of the crosshead, the pin being held in bearings belonging to the connecting rod E and so arranged that the full length of the outer surface of the pin is used to transmit the pressure to the connecting rod E during the outward stroke of the piston, while the two projecting pin ends take the upward pressure on their inner sides. Instead of providing a piston rod with a crosshead pin, as above described, in the case of trunk pistons the upper or inner end of the connecting rod may be provided with a headpiece and pin of a similar type, the complete length of the semi- or part-cylindrical upper surface receiving the thrust on the working stroke of the piston. (*Accepted December 13, 1916.*)

GUNS AND EXPLOSIVES.

100,393. E. W. Bliss Company, Brooklyn, U.S.A. Torpedoes. (5 *Figs.*) May 1, 1915.—This invention relates to gyroscopic steering mechanisms for steering automobile torpedoes. The present invention is based upon the desirability of so locating the gyroscope that its axis will occupy its most advantageous position during the greater part of the run, that is to say, during the straightway course assumed after the initial curve is traversed. A gyroscopic steering mechanism, made in accordance with this invention, is characterised in that the gyroscope is adapted to be moved around the vertical axis of the outer gymbal to a position in which the axis of the gyroscope wheel is substantially parallel with the ultimate straight course of the torpedo. The improved steering device results in the launching being effected with the gyro axis deflected more or less toward the athwartships position, whereupon the torpedo automatically steers through the initial curve until its direction is brought into parallelism with that assumed by the gyro axis,



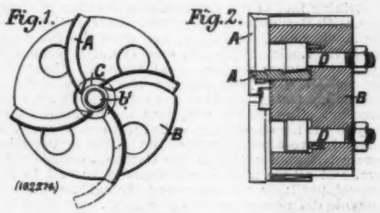
and upon such parallelism being attained the torpedo then steers its straightaway course, such course being parallel with the direction of the gyro axis. Thus for the major part of the run of the torpedo the gyroscope is in its most effective location. A is the torpedo, the dotted arrow *a* showing its longitudinal axis; B is the gyroscope flywheel, the arrow *b* showing its axis of rotation; *c* indicates the course of the torpedo to the target T. A comparison of these diagrams shows the difference introduced by the present invention. Heretofore the gyroscope axis at launching has been in the line with the torpedo axis (Fig. 1), so that after swinging to the ultimate course the gyro axis is more or less transverse to the torpedo axis, that is, to the direction of the straightaway course. By the present invention (Fig. 2) the gyro is turned before launching through as many degrees as the angular fire, so that when the torpedo is steered around the initial curve the gyro axis and torpedo axis coincide in direction, both pointing toward the target. (*Accepted December 13, 1916.*)

102,390. R. W. B. Billinghurst, Westminster. Fuzes. (4 *Figs.*) January 13, 1916.—This invention relates to fuzes for projectiles. According to this invention, the charge is detonated by the displacement of an independent body, which imparts movement to a spring-controlled hammer or like member, between which and the face of a member opposed thereto the body is held in an unstable position, the opposed faces of the members being each formed as a conical or other concavity, or one of them being so formed while the other is flat. The independent body, which is of spherical or other suitable shape, is thus disposed between two disc-like members, one or both of which is, or are, movable, and the body lies in the conical or other concavity formed in the face of one or each of these members. In this unstable position the body is kept by the action of a spring on one of the members, and it can be displaced from this position by the shock resulting from impact of the projectile. In the preferred arrangement the hammer comprises a flat disc G mounted on one end of a rod E, the other end of which carries the detonating needle E1. The hammer is normally pressed by a spring H away from a cap and detonator disposed opposite the needle. At a suitable distance from, and opposite to, the face of the hammer is a hollow conical surface B, which is conveniently formed on a part of the outer casing of the projectile. This conical part may be integral with the main portion of the casing or may be arranged to have sliding movement with relation to the casing. In the space between the face of the hammer and the conical hollow lies the independent body, which is preferably formed as a sphere J, but it may be otherwise shaped—for

example, as a cylinder with one or both ends conical or rounded. Thus there is formed between the hammer and the opposed conical hollow a chamber, two opposite walls of which are inclined relatively to each other from the centre of the chamber outwards, so that as the independent body J, which normally lies in the centre of the chamber, is impelled radially on impact by its weight, the opposed walls of the chamber will be forced apart with a wedge-like action, with the result that such movement will be imparted to the hammer as will detonate the charge. (*Accepted December 13, 1916.*)

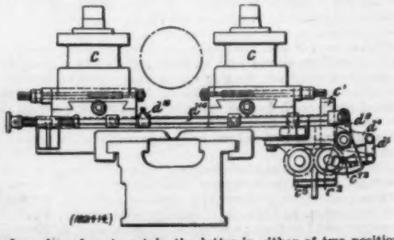
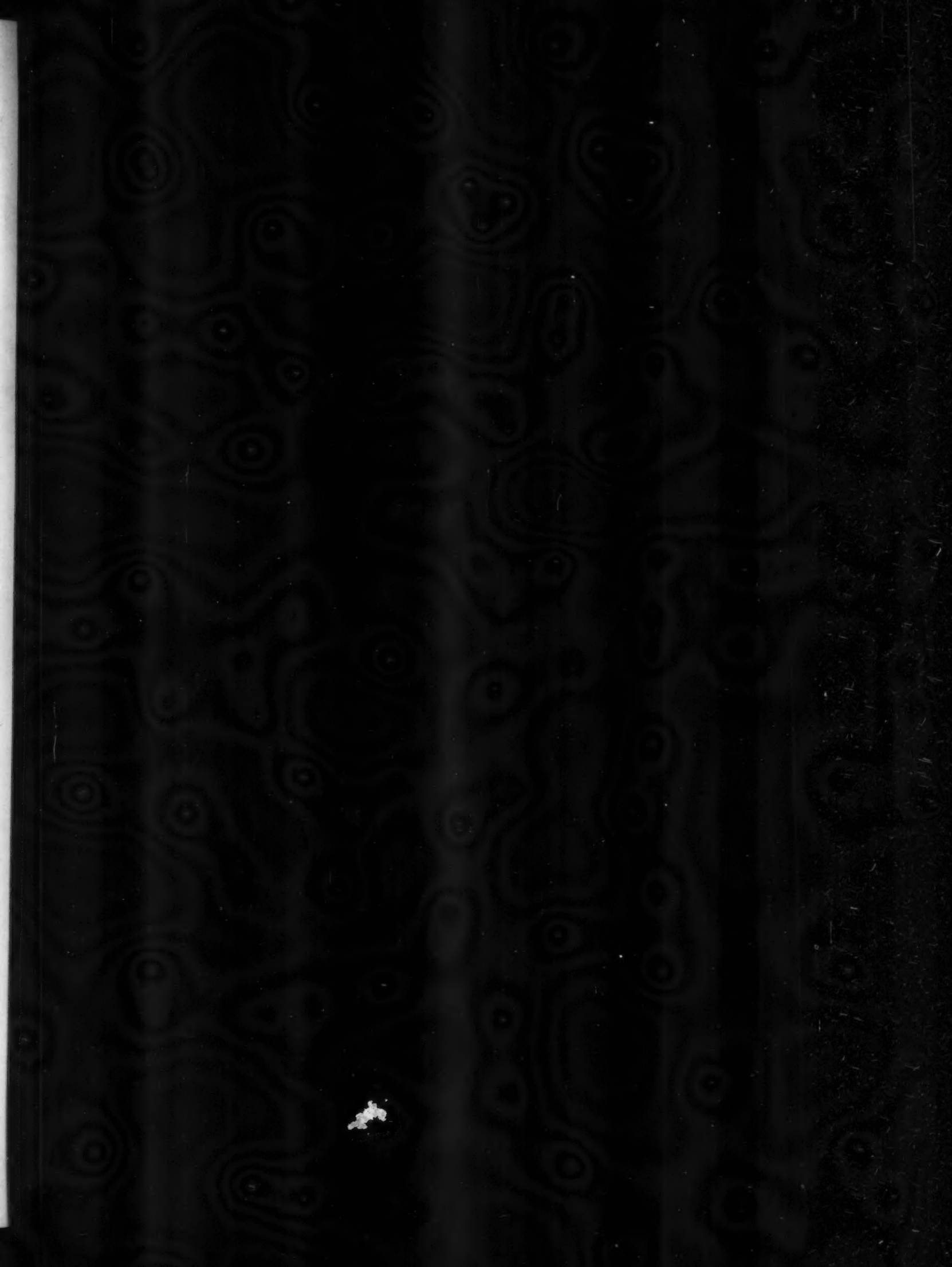
MACHINE AND OTHER TOOLS, SHAFTING, &c.

102,274. Vickers, Limited, Westminster, and H. Francis, Crayford. Milling Tools. (6 *Figs.*) January 4, 1916.—According to this invention, a number of cutting blades A of part cylindrical form are secured with radial adjustment in correspondingly curved slots or channels in the face of a holder B, the blades having a facing edge and also a cutting edge at the inner side which serves for the bossing operation, so that both facing and bossing can be performed simultaneously. The blades are preferably cut from a cylinder which is hardened and ground to shape and then divided into blade segments by an emery wheel, the faces of the blades being afterwards ground on a suitable plate holder, in the recessed face of which they may be fixed by means of a split conical ring with a conical expanding plug or washer tightened up by a screw stud. The finished circular blade segments, when placed in the correspondingly curved deep slots or grooves in the face of the tool-holder B, can be moved in the



slots so as to bring the inner bossing edges to any required distance from the centre of the tool. The adjustment may be conveniently made by means of a loose bushing ground accurately to size and slipped over the end of a central tool spindle *b*1 which projects from a central recess in the face of the holder, the blades being moved inwardly until they meet the face of the bushing, which is removed after the blades have been secured in adjusted position. A convenient method of securing the blades A consists in turning the cylinder from which they are cut with a conical surface and in providing the holder at the side of each blade with a deep recess receiving the head of a screwed pin D, one side of which is cut away to form a slightly coned surface fitting on the conical surface of the blade, the pin passing through the holder to the back, where it is secured by a nut. When the screwed pin is loosened the blade is free to slide in its slot for adjustment (or removal), and on screwing up the nut the pin head firmly grips the blade and holds it rigidly in the adjusted position. (*Accepted December 6, 1916.*)

102,414. J. Holroyd, Ovenden. Machine Tools. (5 *Figs.*) March 3, 1916.—This invention relates to feed-control motions for turning, boring, milling, grinding and other like machine tools, and to that type of apparatus in which a worm drop-box is operated by movement of a sliding stop rod controlled by a stop to disengage the worm from the worm wheel at any predetermined moment when it is required to arrest the feed. The present invention has for object to provide mechanism for accurately disconnecting a power-driven feed when the work that is being operated upon arrives at a given dimension, or is completed. According to this invention, a lever d^9 having stepped surfaces arranged to support a pin or projection c^{12} on the drop-box or bracket c^5 (hereinafter referred to as the bracket)



and so shaped as to retain the latter in either of two positions, is pivotally connected to the slidable stop rod d^{14} carrying one or more adjustably mounted stops d^{16}, which work in conjunction with one or more abutments on one or more tool-holders C, C, and time the action of the lever for allowing the bracket to move to a position to disengage the worm c^6 from the worm wheel c^1. When this takes place the feed is stopped and the tool holder or holders can be returned to their original position, a sliding rod connected by a link d^5 and lever d^4 with the pivoted bracket c^5 enabling the latter to be returned to its operative position, in which position it is maintained by the stop rod and stepped lever being returned to their normal positions. (*Accepted December 13, 1916.*)